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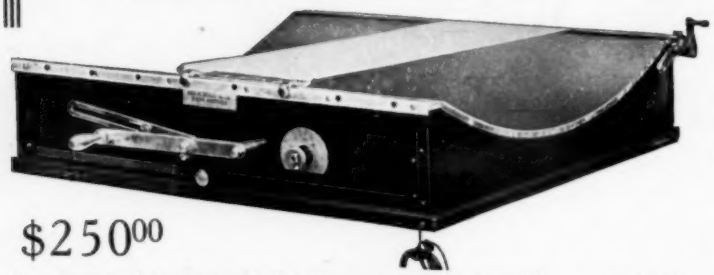

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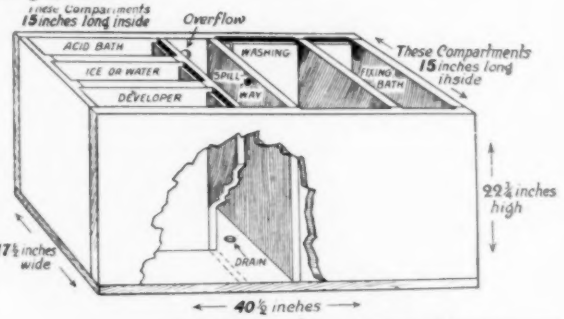

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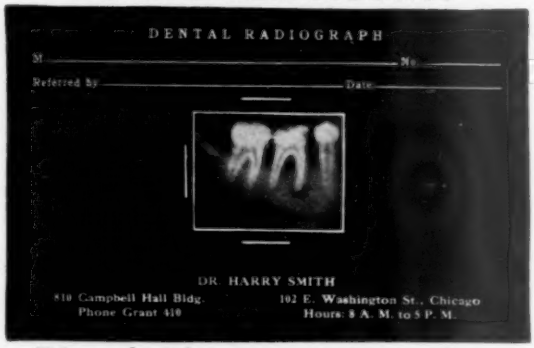

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THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY

VOL. XII DECEMBER, 1924 No. 6

WAVE FORM AND EFFICIENCY: AN ANALYSIS OF ROENTGEN THERAPY MACHINES*

BY

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Stanford University Medical School

SAN FRANCISCO, CALIFORNIA

WE recently calibrated twenty-four high voltage roentgen therapy installations in California and found some twice as fast as others. Such gross differences in output are of serious clinical importance. The possible sources of such differences include errors in measurement of tube current and voltage, differences in tubes and differences in wave form.

TUBE CURRENT

Most machines are equipped with two milliammeters so that failure in an instrument is discovered immediately. We have not found any important errors in milliampere measurement.

VOLTAGE

Kilovolts are commonly measured by sphere gap. Although the error in this measurement may easily amount to several per cent, yet it is entirely insufficient to account for the observed differences in output. Mr. W. W. Nicholas measured the short wave limits of our machine and one other with a spectrometer and found very little difference, yet the output per milliampere-minute was 60 per cent greater from one than from the other.

TUBES

The following table points to what differences may be expected.

TABLE 1

DIFFERENCES IN COOLIDGE TUBES (HIGH VOLTAGE) EXPRESSED IN PERCENTAGES OF AN ARBITRARY STANDARD

Tube No.	History	1 Mm. Al	0.5 Mm. Cu Plus 1 Mm. Al
2U2744	Run 213 hours	100	26.8
2U2512	New	No difference from 2U2744 could be detected	
Same tube	Run 251 hours	98	27.1
V2414	New	88	25.2
V1132	About 600 hours	80	27.3
Same tube	About 1000 hours	79	24.6

WAVE FORM

This brings us to what we believe is the major reason for differences in roentgen-ray output, viz., the wave form. Let us in theory contrast a machine utilizing the full sine wave of potential with one utilizing only the potential crest.

*Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

DIFFERENCES IN WAVE FORM

We have analysed the roentgen-ray production throughout the cycle in two widely different machines. One is kenotron-rectified and so should correspond to the first type shown above. The other is disk-rectified and might be expected to correspond to the second type shown above. Measurement of roentgen-ray output using the same tube (V 2414) and the same filter (our 0.5 mm. Cu) on both machines showed the disk machine to be delivering 2.1 times as much roentgen ray per milliampere-minute as the other.

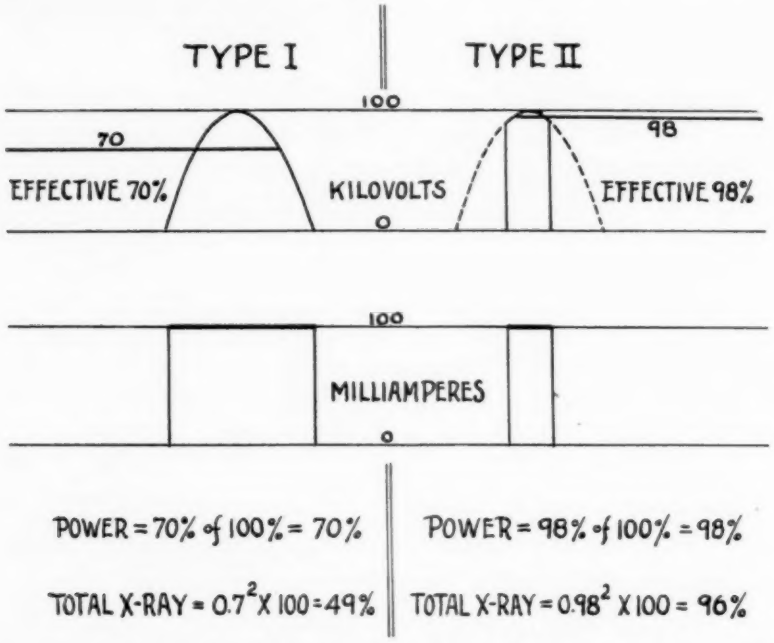

FIG. 1.—The milliampere curves are only a rough approximation. The tube current does not of course become asturated until the voltage has risen to a moderate height.

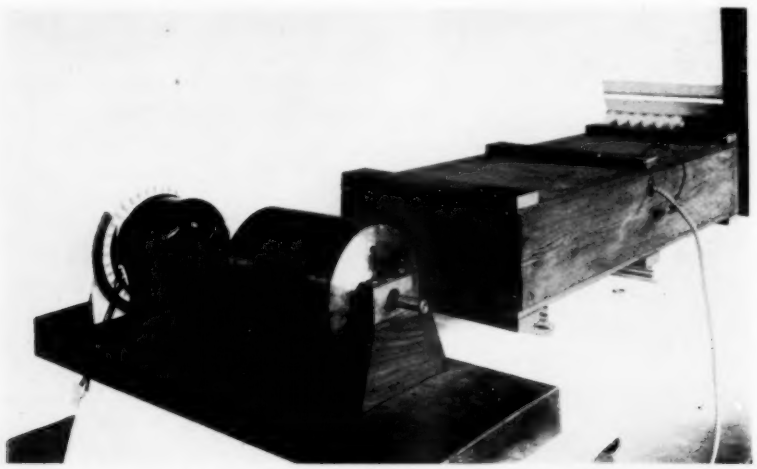

FIG. 2. Large ionization chamber and synchronous shutter for analysing wave form.

We made these analyses by interposing a rotating shutter in the path of the roentgen rays.

This shutter consisted in a lead-lined drum with two 5° slits 180° apart run by a

synchronous motor. The motor ran at thirty revolutions per second, thus making one-half revolution per cycle. Thus the shutter opened once per cycle, remaining open for each point on the target exactly ten electrical degrees (less than $\frac{1}{2000}$ of a second). Using a very large air ionization chamber it was possible to read with a galvanometer the value of each of these 10° samples. In order to avoid errors from momentary fluctuations of roentgen-ray output due to fluctuations in line voltage, we balanced the 10° sample against the ionization current from another ionization chamber placed before the shutter.

By stopping the shutter wide open, it was possible to balance the full 100 per cent against the same reference ionization current. After correcting for the fact that the shutter wide open shaded the margins of the target (factor 0.99) and that while running the shutter required time to open and to close (factor 0.596), the value of each 10° was calculated in per cent of the whole wave.

The following table and graphs show the contrast between a kenotron-rectified machine on autotransformer control and a disk-rectified machine on resistance control. The curves show roentgen rays delivered through three different filters, 1 mm. Al, 0.25 mm. Cu plus 1 mm. Al, and 0.5 mm. Cu plus 1 mm. Al. The area under each of the Al curves is the same. The ordinates show the values of 10° samples expressed in percentages of total roentgen rays. The disk-rectified machine gives 98.5 per cent of its roentgen rays in the middle half of the wave (i.e. during the high voltage portion of the cycle) compared to only 88 per cent from the kenotron-rectified machine in the same portion of the cycle. The figures for the central one-thirds are 84 per cent for the disk and 70 per cent for the kenotron.

From the ratios of filtered to unfiltered rays at different parts of the cycle, it is possible to deduce something of the voltage wave form.

Data for this calculation were obtained by running the shutter to select the crest 10° and interposing the three filters in succession. This was done for twelve crest voltages from 100 kv. to 200 kv. We measured the voltage by sphere gap and modified the values to make them follow smoothly the changes in voltage across the primary of the transformer. Below 110 kv. the copper filtered ray became so weak that it could not be measured accurately. In this region we estimated voltage from intensity through aluminum only. Below 40 kv., however, even these values are too small to be relied upon (0.5 to 0.8 mm. on galvanometer scale). They had best be ignored altogether. It is probable that the disk rectifier really cuts off even more sharply than the above curve indicates.

TABLE II

VALUES OF IONIZATION IN PER CENT OF THE TOTAL IONIZATION THROUGH 1 MM. OF ALUMINUM ONLY, FOR EACH 10 ELECTRICAL DEGREES OF THE HALF CYCLE, FOR TWO MACHINES, TYPES I AND II

Degrees	1 Mm. Al, Per Cent		0.25 Mm. Cu Plus 1 Mm. Al, Per Cent		0.50 Mm. Cu Plus 1 Mm. Al, Per Cent	
	I	II	I	II	I	II
0	0.1	....	0.0	....	0.0	....
10	0.4	0.2	0.0	0.0	0.0	0.0
20	1.0	0.2	0.1	0.2	0.0	0.2
30	1.5	1.4	0.2	0.5	0.1	0.4
40	2.4	4.6	0.5	0.7	0.3	0.7
50	4.4	8.2	1.5	2.9	0.9	2.3
60	7.0	12.3	2.9	6.2	2.0	4.4
70	9.7	16.8	4.8	9.0	3.4	6.3
80	11.9	17.8	6.3	9.7	4.6	7.0
90	13.4	17.7	7.2	9.1	5.4	6.5
100	13.2	14.4	7.0	6.9	5.2	5.5
110	11.8	7.8	6.2	3.1	4.7	2.2
120	9.9	2.1	4.7	0.6	3.4	0.4
130	6.7	0.3	2.6	0.0	1.7	0.3
140	4.6	0.2	1.5	0.3	0.9	0.1
150	3.2	0.5	0.7	0.1	0.4	0.1
160	1.5	0.1	0.2	0.0	0.1	0.0
170	0.5	....	0.0	....	0.0	....
180	....	....	....	....	....	....
Totals....	103.2	104.6	46.4	49.3	33.3	36.4
Integrated	100.0	100.0	45.3	49.3	32.0	35.0

The integrated values were obtained by measurement of the whole cycle with shutter wide open and these were the values used in reducing the analysed data.

CONCLUSIONS

1. High voltage roentgen therapy machines differ by as much as two times in their roentgen-ray output per milliampere-minute even when crest kilovolts, filter,

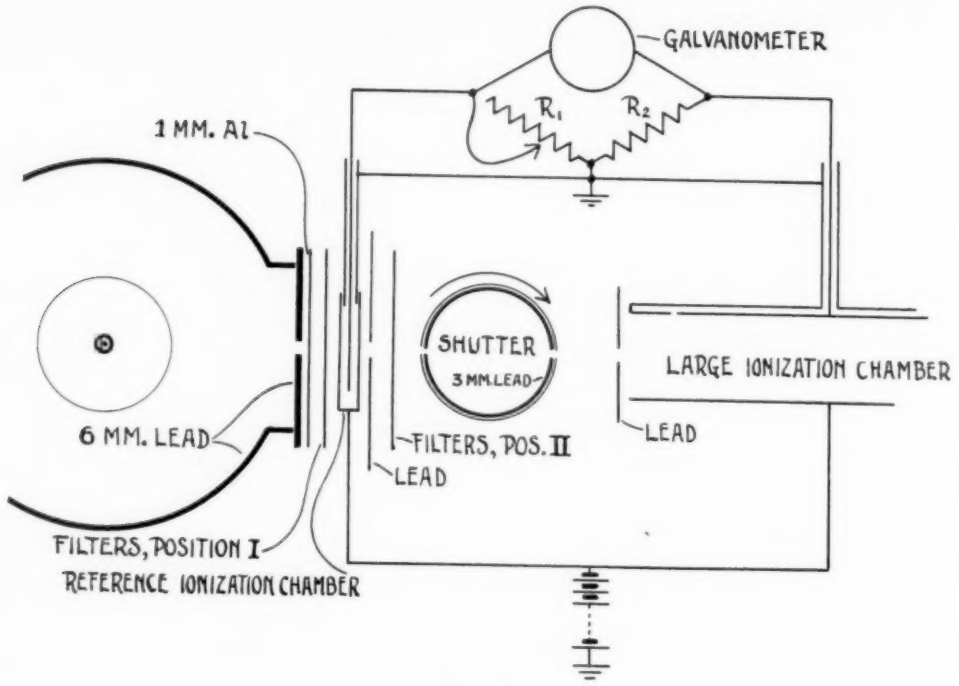

FIG. 3.

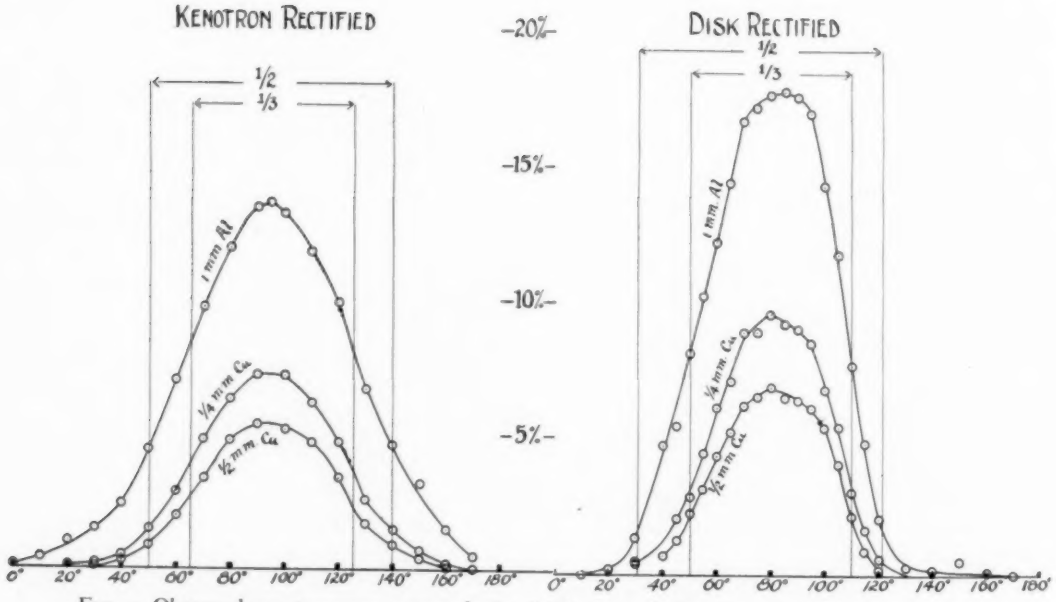

FIG. 4. Observed roentgen-ray output during ½ A. C. cycle for two very different machines.

distance and area and mass irradiated are the same.

2. An analysis of the roentgen-ray output of two very different machines demonstrates gross differences in wave form as the major reason for their difference in output.

DISCUSSION

PROFESSOR GEORGE L. CLARK, Boston. I think that Dr.Chamberlain is to be congratulated for doing a very careful, scientific piece of work. His conclusions are certainly verifiable in any physics laboratory and it all simply goes to show the close cooperation that is necessary between roentgenologists, physicists, manufacturers and all others who are using roentgen rays. If we can all cooperate so as to make the best machine, to get the best and most scientific use out of the machine, we will be doing what science really demands that we should do.

Such a work as Dr. Chamberlain has done is of course of very great importance, not only in the radiation of the human body, but in many other cases. For example, all we have to do in many chemical processes is to use roentgen rays to increase yields enormously. If we take sulphur dioxide plus oxygen, we obtain sulphur trioxide, which is the basis of sulphuric acid. Now, you would be surprised to know that sulphur dioxide and oxygen will combine only in the presence of a catalyst, a metal which does not change itself, which stays just the same, but by some method or other enables the SO_2 and the oxygen to combine and produce SO_3. If we take this catalyst and simply for a few minutes before the chemical reaction takes place irradiate that piece of metal with roentgen rays and then proceed with the experiment of conducting SO_2 and oxygen over the catalyst, the yield of sulphur trioxide is increased 35 per cent, in many cases.

I might give you example after example of the new ways in which we are using roentgen rays in this day. Oxygen combines with benzaldehyde ordinarily with difficulty; with the aid of roentgen rays they will combine at a tremendous rate. Roentgen rays are used in analyzing ceramics, coal, textiles, and paints, even getting down to rubber, metal deposits, thin films, and almost everything that you can imagine.

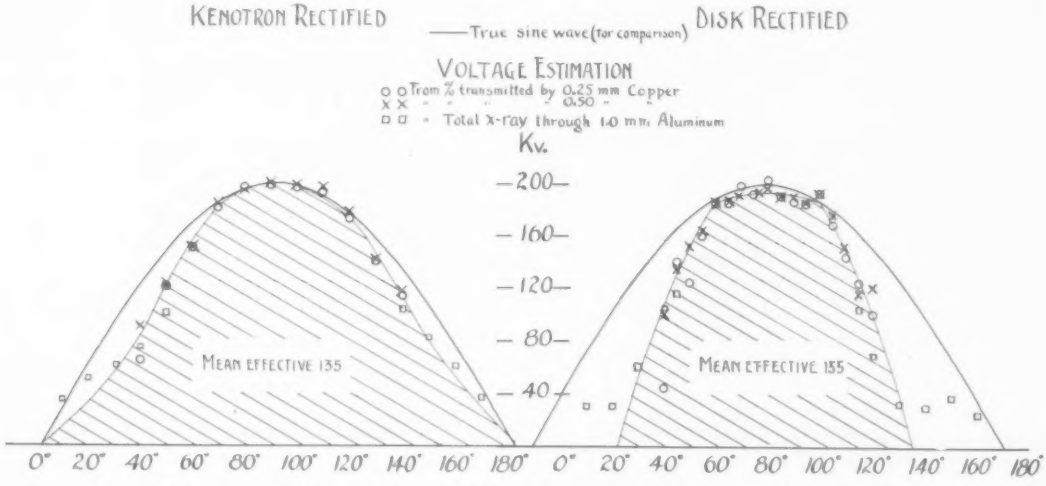
KENOTRON RECTIFIED
——True sine wave(for comparison)
DISK RECTIFIED
VOLTAGE ESTIMATION
o o From % transmitted by 0.25 mm Copper
x x " " " 0.50 "
□ □ " Total X-ray through 1.0 mm Aluminum
Kv.
200
160
120
80
40
MEAN EFFECTIVE 135
MEAN EFFECTIVE 135
0° 20° 40° 60° 80° 100° 120° 140° 160° 180° 0° 20° 40° 60° 80° 100° 120° 140° 160° 180°

FIG. 5. Voltage wave forms estimated from the roentgen-ray outputs shown in Figure 4.

I speak of all these things simply to indicate how important it is not only that you, but chemists, physicists, and everybody else, in the first place, should know what a roentgen ray is, how to handle roentgen rays, and furthermore how to get them in the best possible way, and to get the maximum results from them, so that we will be getting for a given expenditure of power the most radiation. Of course, you see, that amounts to considerable in an industrial process such as I just mentioned.

Certain studies such as Dr. Chamberlain is making and which he has just reported are of tremendous importance industrially and in every other way and certainly we all want to cooperate so that we will get the very best kind of a machine that will give us the very best output for a given expenditure of money. I think we are all agreed on that.

ERYTHEMA AS A UNIT IN DEEP ROENTGEN THERAPY DOSIMETRY

BY EUGENE T. LEDDY, M.D., AND JAMES L. WEATHERWAX, M.A.

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PHILADELPHIA, PENNSYLVANIA

SINCE the advent of deep therapy, introduced by German radiologists and physicists, we have been accustomed to hear of dosimetry based on the erythema dose, carcinoma dose, castration dose, etc., all calculated from and standardised on the erythema, or unit skin dose, so that one reads of 120 per cent H.E.D., 90 per cent U.S.D., 115 per cent E.D.S., etc., as a basis of roentgen therapy technique. Only rarely do we find the complete technique mentioned in results of radiotherapy of neoplasms, the dosimetry being given only as so many per cent of the erythema, or unit skin dose, and little mention is made of the factors by which this dose is obtained. The impression is gained that the standardisation of dosage on erythema gives a fairly absolute basis on which to compare technique and results.

In the literature are given various standard erythemas all of different value, although it is true that between some of them there is close agreement. Some of these units of dosage are calculated in absolute electrical units of ionisation current, measurements being made in the centimeter-gram-second system, the value being expressed in (e). But even on this basis dosimetry is not as absolutely defined as the selection of such an absolute standard might lead one to believe. Most of the measurements were made by iontoquantimetric determinations of roentgen intensity checked against a radium standard, but unless one is in position to duplicate the electrical and ionisation systems by which these measurements were made, their value and fixity cannot be checked up exactly.

Seitz and Wintz define a "unit skin dose" as the quantity of radiation which eight days after exposure produces a slight hyperemia and four weeks after a slight tanning of the skin.[1]

Kroenig and Friedrich set their unit differently, and define it as a "first degree erythema" placing this value at 170 (e). Duane and Bachem have both set their erythema value at 1800 (e), using the technique commonly used in deep therapy. According to Bachem[2] this value produces a mild erythema. At 1500 (e) there is the first indication (in some cases) of reaction; 2100 (e) gives a definite reaction. The erythema value set by Schmitz corresponds with that of Friedrich. Fürstenau says that 120 F. are necessary with hard rays to produce an erythema.

The conclusion reached from all these standards is that the reactivity of normal skin to short wave-length roentgen rays is definable in narrow limits, set at from 15 to 25 per cent, accurately determined from a physical point of view, so that clinical dosimetry is definable on a more or less absolute physical basis.

In the literature are found charts and tables taking into consideration variations of dosage and of time, both depending on the erythema varying with the size of the port of entry through which the patient is irradiated. Dessauer, Friedrich, and Bachem all agree that the patient is best irradiated through the largest port consistent with clinical findings. Theoretically in decreasing a port of entry from 20 cm. square to 5 cm. square, the time of production of a uniform erythema has, in the latter case, to be increased by 30 per cent.[2] Friedrich[3] says that "after a certain size of field (about 20 cm.) has been attained a further increase in the size of the field does not exert any influence on the time duration of application of the dose in the center of the field."

Most of the figures taking into consideration the importance of the size of the field are based on physical measurements of depth dosage, and but little mention is made whether these differences of intensity on the surface have been subjected to clinical control. It is questionable from the literature so far investigated whether

the differences in reactivity of normal skin do show the variation which one would expect following a surface variation of, say 30 per cent, of which so much is made in deep therapy dosimetry on a physical basis.

In the field of roentgen therapy many observers have called attention to the hypersusceptibility of some patients to doses under quite absolute physical control. But no idiosyncrasy, properly speaking, to roentgen rays seems acceptable. In most cases of burn resulting from doses theoretically safe, the rays were filtered at most through only a few millimeters of aluminum, and were of a far softer nature than those commonly used in deep therapy. The inference could be drawn that when using a soft radiation the margin of safety is narrower than when heavily filtered radiation is used, especially since it is well known that skin and tissue reaction generally depends on absorption of radiation, and that soft radiation is more completely absorbed in the upper tissue layers. However, these observations are not checked up by very accurately controlled dosimetry in most cases.

Kroenig and Friedrich[3] cite the fact that cachectic patients show a lowered reactivity to doses which in noncachectic patients produce a "normal erythema." This observation is confirmed by Bachem. However, the statement that normal skin shows within narrow limits a uniform reactivity to uniform doses of roentgen rays is usually accepted. Friedrich has set the limit of variation at about 25 per cent and Wintz and Rump[4] say: "We wish to conclude this short exposition with the suggestion that the explanation of differences in reaction of the same kind of cancer mentioned in the literature should not be sought for in biologic factors. It must be shown first of all that the physical factors were checked up, and whether really, in spite of a varying effect the same dose actually was given. We know at present of neither a varying reactivity of normal skin, nor a varying reactivity of portio-carcinoma, no matter whether the patient is young or old, or the cancer early or advanced."

Failla[5] has said that the uniform susceptibility of normal skin to uniform doses of radium emanation is not observed. For that reason he prefers to base his dosimetry on a "threshold" value of erythema, rather than to speak of low, average, or maximum reactivity. His standard is the minimum millicurie hour dosage with a certain filtration that will produce a reaction in some patients. These conclusions have been confirmed and elaborated by Dean[6]. The value assigned by him has been criticized by some physicists as being rather low. But the point to the studies of Failla and of Dean is that there is a variation in reactivity of normal skin to as accurately definable a source of radiation as that from radium.

On the physical side of roentgen therapy there are many variables, especially in the quantity and quality of the radiation. These are complicated by little-understood biologic reactions of both the patient and his tumor. The main variables usually considered are the current by which the tube is run, and the roentgen tube itself. (Little attention is usually paid to the biologic factors in therapy.) However, it is affirmed that one can clinically compensate for these by accurate dosimetry during the actual treatment of a patient, and that fluctuations in the same apparatus with the same set-up are very slight when observed from day to day.

For the determination of the clinical dose a considerable number of iontoquantimeters have been devised. By their use an accurate dosimetry on a basis of time alone has been established. For this reason complete technique is rarely given, but is reported as the per cent of erythema value so established.

We have previously shown[7,8,9] that from a physical point of view the one hundred per cent, or erythema value was subject to considerable variation, depending on the standard taken on which these measurements were based. Although depth dose was mentioned only incidentally, it was pointed out that a considerable variation in it was noted, depending on the hundred per cent (skin dose) taken. It seemed as if clinical dosimetry would also vary. For this reason a plea for standarization was made.

It did not seem to us as if with the same intensity of radiation applied for a uniform

length of time the same reddening of the skin was noted. Similarly it was observed that a considerable variation, both in intensity and in time, gave a reaction of the skin definable as an erythema. It seemed advisable in the face of such observations to assure ourselves that a uniform dose of roentgen rays actually was administered in those cases where a variable skin reaction seemed to be noted.

In the above articles we have described two iontoquantimetric systems applicable to clinical dosimetry. The large-chamber galvanometer type, as was mentioned, seemed best suited to our needs in measuring surface intensity. This apparatus, as was mentioned, needs no special attention, reads constantly the dose in arbitrary units while it is being administered, and can be checked up by the horn chamber system as reading constantly from day to day when calibrated against both meters and sphere gap.

The roentgen-ray apparatus we are using has been checked up by the electroscope and galvanometer systems, against radium, and has been shown to give with the same Coolidge tube a uniform roentgen output with a constant control setting. Repeated checks have shown that with the same electrical factors and a given filter a constant deflection of the galvanometer mirror is noted. As was mentioned in the paper, accurate dosimetry during a treatment was facilitated by this instrument, assuring us that a patient actually was getting a known measured dose of radiation.

In the literature there seems to be no agreement on the degree of redness an erythema should embrace. It appears to be a purely relative term, depending on the judgment of the radiologist making the observation. It seems quite improbable that a scale of erythema value, comparable to a hemoglobin scale, for example, would have any practical significance, for the problem of the obviation of normal skin pigment in the estimation of redness due to radiation is one not easy of solution. Furthermore, clinicians may differ among themselves on the time of appearance and intensity of redness on the normal skin of the same patient. In fact, they may even debate its presence at all in border-line cases. It would seem better therefore, that the solution of the erythema as a basis of dosimetry be left merely to its presence or absence, without a consideration of its intensity, for fine definition of the intensity of a first degree burn is a question of more academic than practical importance.

It is unlikely that the human body would react uniformly within narrow limits to any medicament, for it is in this light that therapeutic roentgen radiation is to be regarded. But before this can be affirmed uniform dosing and non-uniform response, or varying dosage and uniform response must be demonstrated in a sufficiently large group of cases.

The present report will confine itself to the technique most in vogue in this country in deep therapy. The following constant factors will be assumed:

200 kv., max, on the tube.
4 milliamperes.
50 cm. target-skin distance.
0.62 mm. copper plus 2.3 mm. aluminum.
Coolidge tube.
Radiation in a single sitting,

and the only variables the time of exposure and the size of the port of entry.

The roentgen apparatus we are using is a regular "20-inch" machine.

Our iontoquantimeters were such as previously described.

Before iontoquantimetrically measuring roentgen-ray output a standardisation of the apparatus was made by meter checks against a standard 125 mm. sphere gap. Primary and kilovolt meters were simultaneously checked at the spark-over.

The milliammeters on the control stand and "tank" tube-holder were checked against a standard meter, and the difference between the two, due to line loss, was found constant from month to month.

The thickness of the filters was determined by micrometer measurement.

A brass rod 13 cm. long placed between the center of the floor of the ionisation chamber and the skin of the patient enabled us to get easily an accurate target-skin distance of 50 cm. (barring an error of less than 5 mm.). The body of the patient

was levelled on the table in such a way that the complete port of entry under consideration was uniformly 50 cm. from the target of the roentgen tube.

With the "tank" tube holder at our disposal the maximum port of entry at a distance of 50 cm. is 26.6 cm. in diameter.

As ports of entry we have used ⅛-inch lead screens in which a hole, either circular or square, was cut to known dimensions. The screens have been maintained at a constant distance of 5 mm. from the skin of the patient by means of a special holder. The actual increase in the size of the radiation cone due to the screen not being in actual contact with the skin, when using a port of entry 20 cm. in diameter at 50 cm. target skin distance, is about 0.6 per cent. It might be said in passing that in no case was there overlapping of the irradiated areas if adjacent ports were chosen, the reaction being confined to the port theoretically exposed.

We regard erythemas with and without vesication as distinctly different skin reactions, and do not differentiate mere differences of intensity of reddening.

For the purpose of comparison we have arbitrarily set 100 minutes as the average time of erythema production with the aforementioned factors and a port of entry 20 cm. in diameter. This in *all* cases so far observed produced a reddening of the skin distinctly visible, coming on about the tenth day, lasting about two weeks, and fading to a bronzing in about a month with no skin changes other than the pigmentation.

With other factors remaining constant, it was found that this average time could be increased to 130 or decreased to 80 minutes, a reddening of the skin being noted in all cases, but without a distinctly different skin reaction. It must not be understood, however, that the same intensity of redness was noted at the maximum and minimum time values. But both reactions are first degree burns, and so meet the definition of erythema. However, not all cases irradiated with a uniform technique for 100 minutes were equally red. We were unable to demonstrate with any time of application a uniform reddening of the skin with these constant factors, no matter whether the patient was or was not cachectic.

In a group of patients irradiated with the constant factors for 75 minutes some reacted with an erythema and some did not. We assigned this as the "threshold" time of reaction with our outfit. At 135 minutes most patients reacted with a vesication. The maximum scale of variation in time of skin reactivity is, with the radiation we are using, about 55 per cent.

It were tedious in a report such as this to include case histories of patients irradiated, or detailed notes on skin reactions. But it should be mentioned that in all these observations homologous regions in the same or different patients were compared, both being irradiated with the same technique. We have given here, therefore, only the conclusions reached.

These observations have been made on a sufficiently large group of patients to enable us to say that there is a maximum variation of at least 50 per cent in the time in which a reaction of normal skin definable as an erythema can be produced with roentgen rays from the factors given.

When, for example, a 2 cm. and a 20 cm. port were irradiated on opposite sides of the midline of the abdominal wall of a patient with the standard-average time of 100 minutes, both ports responded with a reddening. We have at our disposal at present no method of determining the difference of the intensities of such redness. Both reactions met the definition of an erythema. The size of the port of entry in this case had a bearing on the intensity of redness only, not on its presence or absence.

If four ports were rayed with the constant technique for 100 or any other number of minutes down to 80 or up to 130 minutes, and ports of 2, 4, 8, and 16 cm. were chosen, all responded with a reddening. Yet we have increased the area of exposure 64 times.

If we irradiated two, three, or four ports of any given size on one patient—avoiding cross fire—for the same time, we have observed no uniformity of reddening. If we irradiated similar portions of the body of different patients with the same technique we have observed no constancy of skin reaction.

If we selected a circular, or a square port of entry 10 cm. in diameter and compared it with one 6 by 8 cm. on homologous parts of the body of patients irradiated with the same technique no conclusions could be drawn from the skin reactions about the intensity of radiation applied.

No matter what our technique, provided it was kept constant, we have observed very little uniformity of reactivity of patients. It has repeatedly occurred to us that the size of the port of entry is less important than imaginable from a physical point of view. For the human body has, in our experience, not manifested the power of discrimination between radiation intensities varying over a field of 50 per cent as evidenced by a distinctly different skin reaction, no matter whether the patient was or was not cachectic.

We are not here concerned with differentiation of reactions of the skin definable as erythemas; nor with the exact percentage of its variability; nor with intensity measurements in the depths. We do not at all contradict the conclusions of the physicists on differences of intensity when small ports of entry are compared with large. What we wish to point out is that the skin reaction definable as an erythema is obtainable in limits as wide as those mentioned, and that normal skin does not react uniformly to uniform doses of heavily filtered roentgen rays.

It is obvious that an erythema in itself is no criterion by which depth intensities can be judged, as it can be produced by both "low" and "high" voltage radiation. We have shown here that an erythema is no accurate measure of surface intensity. With such a latitude of variation on the surface as we have found it is fair to assume a parallel variation in depth intensity, and therefore in biologic effect on subcutaneous tissues.

We suggest, therefore, that inasmuch as erythema is a loose standard on which to base technique, all reports of radiation therapy be given in their entirety, so that comparisons can be made. Until some definite biological or clinical or physical standard of dosimetry has been established the whole story of therapy technique should be given, otherwise there can be no close agreement among the various clinics on results of the treatment of cancer by roentgen radiation.

CONCLUSIONS

1. The erythema (skin unit) dose is a flexible, arbitrary, inaccurate standard.

2. Dosimetry based on it has a relative value individual to the judgment of the radiologist.

3. If used as a basis of comparison of technique its threshold value is more practical than its intensity.

4. In reporting technique in therapy full data should be given until a definite standard is established.

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OBJECTIONS TO THE USE OF RADIUM EMANATION IN BARE TUBES, WITH CLINICAL AND HISTOLOGICAL OBSERVATIONS*

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THE aim of radiotherapy in the treatment of cancer has, until recently, been the direct destruction of the malignant cells. It is gradually being recognized that this is not only a wrong point of view, but also that it is a physical impossibility to kill directly all the malignant cells in a cancer mass. It is true that when an intensive radiation dose is applied to an area occupied by a cancer, most of the malignant cells are killed outright, but many normal cells of the surrounding tissues likewise suffer destruction or grave injury. This, no doubt, explains the many recent statistics which show that with increased intensity of radiation an increased percentage of recurrence is noted.

Evidence is accumulating that the normal body cells possess some latent power of resistance to cancer cell invasion, somewhat similar to that which they possess to overcome the invasion of any other foreign cells. It is true that these powers frequently seem to lack initiative or to be totally inadequate to the demands made upon them, as in those cases where we find a tumor composed of rapidly growing cells showing no differentiation. On the other hand, in proportion as these powers are present we find tumors showing more and more cell differentiation. In these cases, too, are sometimes found evidences of body reaction, as shown by the presence of a leucocytic infiltration of the diseased area, the vacuolization and loss of staining power of many of the cancer cells, and other evidence of their death, and of their replacement by fibrous connective tissue. May we not, with reason, regard a scirrhous carcinoma as one in which this stage is well advanced?

Now, in the radiations of radium we have an irritant, the intensity of whose action on the tissues we can vary at will (filtration).

Instead, therefore, of using such an intensity as to kill the cells, both malignant and normal, over the area in which the greatest radiation concentration prevails, namely, the tumor, might we not do better to forget the cancer, for the moment at least, and give more consideration to the normal cells of the host. If by mild irritation we could stimulate these cells to some such reaction as referred to above, might we not reasonably hope to kill the cancer cells indirectly and cause their replacement by moderate fibrosis without subjecting the patient to the discomforts and dangers of intense radiation? In proportion as a tumor consists of new fast growing embryonic cells, it is the more readily affected by radiation treatment. In such tumors, therefore, we might expect that radiations sufficiently mild to stimulate the normal surrounding tissues would still have power enough to depress, if not to kill these embryonic cancer cells. Clinical observations would seem to support this theory. On the other hand, the sensitivity of the cells of such tumors as show marked cell differentiation would not vary greatly from that of the surrounding normal cells and would not, therefore, suffer any depressing effect from the mild radiation. This, too, has been observed clinically. As this mild irritation does not cause proliferation of the normal cells, there is no reason to fear an increased activity of the cancer cells, nor is there any clinical evidence to indicate that this occurs. The effect on the tissues of mild, frequently repeated radiation is a marked leucocytic infiltration, a loss of cell outline, hyalinization, etc. The radiations from radium are, of course, not homogeneous. The alpha rays are so readily absorbed that they need not enter further into our present considerations. Nor need we consider the physical differences of the beta and gamma rays. Clinically their principal difference lies in the fact that the beta rays act as a more intense irritant than do the gamma rays, on account of the greater penetrative power of the latter. For

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the same reason the gamma rays produce a greater number of secondary and scattered radiations in the tissues. The intensely irritating effects of the beta rays have been frequently demonstrated where radium has been used with insufficient filtration, the result being an intense reaction in the tissues, marked sloughing, and a resulting heavy fibrosis.

When applied to a malignant tumor, this action on the cancer cells is accompanied by a devitalizing effect on the surrounding normal cells, which we are fast learning to recognize as being what we must avoid. To quote a sentence of Ewing's in the Mütter Lecture before the College of Physicians in Philadelphia on "An Analysis of Radiation Therapy in Cancer," ". . . when one proceeds in deep therapy on the theory that therapeutic results depend not only on injury to tumor cells but also on defense reactions of the body and tissues, the immediate results seen seem to be most equally striking, and the end-results often more satisfactory, and the treatment is conducted with less damage and danger to the patient."

Much of the danger of hyperirritation may be obviated by using sufficient filtration to remove all radiations except the gamma and perhaps the hardest of the beta rays. Shortening the time of exposure will, of course, also, lessen the danger of hyperirritation.

By using fixed quantities of radium, with filtration sufficient to absorb all but the hardest rays, our remaining variable factor will be that of time.

To radiate equally all parts of a cancer, the radium must be buried at regular intervals throughout the growth, or "cross-fire" technique used from the surface. As this latter method does not enter our present discussion it need not be considered, though in many malignant conditions it has great value and many advantages.

There are two principal methods in use for burying the radium, namely, emanation in capillary glass tubes, and the element, or emanation, in metal alloy needles.

From our experience with capillary tubes containing from 0.5 to 1.0 mc., we object to the use of emanation in this manner, for the following reasons:

(1) We know that one of the causes of cancer is prolonged irritation. It seems irrational, therefore, to scatter in the tissues ten, twenty, or more minute, hard, foreign bodies; particularly so in tissues where considerable movement occurs, such as those of the tongue, muscles of the neck, etc.

(2) Theoretically these tubes should be planted at equal distances in the tumor to produce an even radiation, but, practically this is almost an impossibility. Several tubes will certainly be planted too close to one another, resulting in a local overdose; while other parts of the tumor will receive, conversely, insufficient treatment.

(3) The glass walls of these tubes are not thick enough to filter out sufficient of the beta rays, hence there is frequently produced an intense local reaction, followed by sloughing, great pain, and heavy fibrosis, which so cuts off all circulation to the part as often to result in further necrosis.

(4) When once the tubes are planted we lose all further control over them.

(5) The prolonged action of the emanation in buried tubes appears to have a particularly devitalizing effect on bone.

(6) In our experience pain is almost always a severe and persistent symptom.

On the other hand, the advantages of using radium or emanation in metal alloy needles are:

(1) The needles being in the tissues for a regulated time only and then withdrawn, no irritating foreign body remains.

(2) With needles of different sizes and lengths it is not impossible nor a very difficult matter to imbed the emanation or element at comparatively equal distances throughout the tissues.

(3) The hyperirritating beta radiations are filtered out and their undesirable effects therefore avoided.

(4) The time factor is under perfect control.

(5) Bone necrosis has been observed to be much less frequent with the needles.

(6) Pain is certainly much less than with buried glass tubes.

The following will serve as an example of the difference, in our experience, of the

effect of buried tubes and needles: In a case of squamous cell carcinoma, in which two glands of the neck were involved, needles were imbedded with the result that the indurated glands completely disappeared. Some time later another gland became enlarged and indurated. On this occasion buried emanation tubes were used, with most unfortunate results. A deep slough was produced, which finally involved the subclavian artery, with a rapidly fatal termination. The results of many cases which we have observed in other institutions confirm our own experiences—as, for example, a case of carcinoma of the tongue which was treated with buried emanation tubes. The result was a slough which involved the thickness of the adjacent cheek. Where sloughs are desired, either of the soft tissues, or of bone, we have found by experience that they can be produced with ease and perfect control by the electrodesiccation or coagulation method, without subsequent pain and heavy fibrosis.

It is true that we have had several good results following the use of bare tubes, but the patients have suffered untold torture before experiencing relief.

In a large hospital it may not be economically possible to use the element in needles when dealing with a large number of cases. Under such circumstances there may be ample justification for the substitution of emanation in bare tubes. Emanation in needles offers the same advantages, of course, as does the element, with the further advantage that it possesses comparatively no commercial value in case of loss. The disadvantage of its use in this manner is the necessity of making frequent estimations of its radiation power.

We believe that bare tubes may be of value in a few exceptional cases, such as those where anatomical relationship prevents the use of needles.

ABSTRACT OF DISCUSSION

Professor Cl. Regaud, Paris, France. I agree with Dr. Morgan on nearly all the points of his paper. The first statement upon which I disagree is that in which Dr. Morgan affirms that the action of the rays upon the cancer cells is not direct but depends upon the surrounding tissues. I think that the action of the rays upon the cancer cells is a direct one.

The second point for discussion is in regard to the use of the bare tubes. Dr. Janeway's method of bare tube implantation has made great progress in introducing the bare tubes, but not because the tubes are used do we get the beta radiation and the soft gamma radiation. In my opinion the reason for the success of his method is not because we get beta and soft gamma radiation, but because, first, in that method many small foci of radiation are possible; second, by the use of many small foci the dose given by this method is equally distributed in all the cancer tissues; third, because the length of time of radiation is much greater. The treatment is protracted by the use of bare tubes during many days, and perhaps this was not absolutely intentional. I have tried to eliminate the caustic effect of the beta rays and soft gamma radiation by heavy filters of platinum and gold and with those heavily filtered tubes we can still retain the advantage of multiplication of foci, having as many as may be desired. Also we can vary the length of radiation as desired. One of the advantages of the bare tube method is to use a small dose in each focus. This is obtained also by the filter needles. First, multiplication of foci, second, length of time, and, third, the small doses, I believe are the advantages.

The bare tube method has still very definite and useful indications. There are some types of cancer that are not very susceptible to heavily filtered radiation. Some of these are nevocarcinomata and small carcinomata and fibromata. Also in the very special epitheliomata that are small, the growths can be destroyed locally without much reaction in the surrounding tissues, and in these the use of bare tubes is recommended because there is no surrounding necrosis. The use of the bare tubes is also recommended where we have to treat carcinoma in parts not readily accessible, as in the soft palate and inferior maxilla.

Another point is that according to my ideas it is not well to replace the heavy filters, like platinum and gold, by low density filters, such as steel. I believe the steel needle method is not so good as the bare tube method. The steel is a better filter than glass, but it is not a sufficient filter to use with the dosage that comes from the use of the bare tube. There is the same caustic reaction from the steel as from the glass needles and much of the beta reaction and soft gamma reaction, and hence we have the reaction that we wish to avoid by heavy filtration.

One last point is that the distribution of the radioactive substance in the needle is very

important. The needles should have a short point and a short eye so that the whole length of the needle may be filled with radium element or emanation. The short point needle in which there is only a small quantity of radium near the point will bring disastrous results, because often the experimenter will think the upper part is filled with radioactive substance while only the lower part is useful for treatment. I use only the long needles and in them use two emanation tubes of 1.5 cm. each in length. This gives each needle 3 cm. distribution. In a tongue cancer, if the cancer occupies one-third of the organ I apply ten of the long needles. If each needle has 3 cm. of radioactive substance the ten needles in the cancer growth will have 30 cm. in length of radioactive substance, and nearly every point of the cancerous tissue will be treated by homogeneous rays filtered by this heavily filtered needle. The emanation tubes measure one millicurie per centimeter length. The needles are 0.5 mm. of platinum in thickness of the wall.

Dr. James Ewing, New York City. I feel most strongly that this is the critical point in radium therapy. In listening to the very clear explanation of Professor Regaud I welcome his ideas of what we are willing to call ideal radiation therapy. I am well aware that we introduced through the work of Janeway, the caustic type of therapy. I thought it was a very doubtful step, and that if we had to kill cancer cells by producing caustic results we might as well abandon radium therapy and go back to surgical effort. Therefore, I feel that any effort that can be made to do away with the caustic effect of radium is to be welcomed and aided in every way. I feel that in Professor Regaud's efforts we have the best hope that radiation will be saved from this destructive way of destroying cancer cells.

I think that Dr. Morgan's exceptions to the seeds are well taken. I know for a long time it seemed impossible to cure tongue cancer by filtered radiation. Professor Regaud indicates from his results that by the proper use of filtered platinum needles he is able to control squamous cell carcinoma of the tongue and mucous membranes. If he is, I am sure we will be most happy to abandon these caustic methods in favor of the filtered radium, but it will be a question of what proportion of cures are secured by the milder methods. If we can control disease better with the milder methods of filtered needles we will have to abandon the use of the bare tubes.

I was greatly pleased to have Professor Regaud emphasize the fact that bare tubes are of advantage in certain resistant tumors. He mentioned nevocarcinoma. I would not hesitate to implant all the bare tubes in such tumor tissue that the patient can stand. He mentioned the fibromas as a type of tumor which resists the caustic action. As he states, all the highly resistant tumors can be safely treated by the seeds. I do not feel that the time the minute glass tubes subsequently remain in the tissues is important. They are innocuous foreign bodies and so far as I can see they have done no damage.

There is another group of cases in which the use of the bare tubes will probably be advantageous—mammary cancer. This is a resistant type and the sooner we recognize this, the more satisfactory will be our treatment of the primary growths. I think in massive tissues one can safely implant radiation in massive doses in bare glass tubes, without any material damage, and the result will be satisfactory.

If we can cure advanced carcinoma by introducing platinum filtered tubes, by all means let us do it, but if we cannot, then the only alternative, it seems to me, is to improve the use of the bare tubes by more accurate application, with protection of the surrounding tissue, by shields if necessary, to remove the possibility of infection because infection is very bad at times, and this reduces the pain and unpleasant sequelae that follow this method.

Dr. Douglas Quick, New York City. I welcome the opportunity to say a few words in defense of the bare tubes. We all recognize the pain and unpleasant sequelae that go with their use, but I think we are coming to a better technique. We started in 1916 using 2.5, 3 or even 4 mc. in our tubes. You have all seen some of the results that followed and which we think now are unjustifiable. Year after year the value of the tubes used has come down lower and lower. We also now have deep roentgen radiation, and that again allows us to drop the bare tube down a notch lower in strength.

Another point in favor of their use is in the treatment of primary ulcerating growths, especially in mouth cases. During the last year I have been trying to keep the mouth clean by using mouth washes and by painting the surface with mercurochrome solution, and it is surprising how much can be accomplished by such cleanliness, and leaving the radium to do its work more or less alone. We obtain a much less severe reaction. We must not think that the bare tubes are to be used anywhere and everywhere. In the ulcerating lesions as in the mouth, where only palliation can be hoped for, they are too severe.

In regard to element needles, with the exception of a few of the smaller ones, we must

admit that they are large sized affairs. That is the only criticism I can offer of Professor Regaud's needles.

I think one might raise a question about the strength of the radiation from end to end. Somewhere in the middle of the needle the patient will get more radiation than at either end, no matter how carefully one plans. I do not believe one can get as even a distribution of the radium energy as with the bare tubes carefully placed. He misses the factor of prolonged radiation by using the weak needles and leaving them in for several days.

As to ease of application both for operator and patient, the bare tube is much more easily handled and the trauma is less. Dr. Ewing has stated that we have seen practically no bad results from them from the standpoint of foreign bodies. They do create a severe inflammatory reaction with resulting necrosis, but we have not seen bad results from that either. The prolonged radiation is greater than by leaving the needles in.

Dr. J. E. Gendreau, Montreal, Quebec. I have had no experience with the method employed by Dr. Regaud but am pleased to hear his discussion. My own method dates back three years, in which time I have used bare tubes and was very much distressed to see the suffering described by Dr. Ewing. During the last two years we have reduced the amount of radiation by implantation. Inside the mouth we never use more than 5 mc. altogether along the mouth and jaw, and sometimes the tubes are as low as 0.25 mc. each. This, supplemented with the high voltage apparatus roentgen rays has yielded, I believe, very satisfactory results, with a great diminution in the amount of pain and sloughing encountered in the old method. I believe we should bend our efforts to the prolonged radiation.

Dr. Morgan, closing. The question of the exact action upon the cancer cell whether it is directly destructive or indirectly by means of the tissue reaction, still remains to be determined. I believe that both actions occur. Cannot we so treat our cases as to reduce the cancer cells to such a condition that they will be carried away and destroyed in a more normal manner, and by so doing avoid these unfortunate and unpleasant complications which follow the heavy dosage?

In connection with roentgen radiation, we have recently been doing some interesting work in using a small time factor and reducing our usual erythema dose of 320 ma-min., with most remarkable results. We get good results with three minutes twice daily, using the other factors the same as before. It is too soon to say that any cures have resulted, but the results thus far have been interesting. I think the effect on the tissues is vital and important and that we should not strive solely to directly destory the cancer cell.

Professor Regaud's remarks about using emanation in the needles are interesting and I am glad to hear them, but they do not apply to our paper, which was on the subject of the use of bare tubes. I think the workers at Memorial Hospital deserve much credit for their pioneer work along this line. Naturally they have made mistakes, as we all have, and are learning that such methods have to be modified, but I think some happy medium will be the result.

We thought it was an opportune moment to bring up this subject because so many of the companies handling radium are introducing it. When used by those who know how to employ them properly, satisfactory results will be obtained by bare tubes, but if applied by those who do not understand their use much harm will result.

RADIUM IN LESIONS OF THE FEMALE URETHRA*

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IN this paper we wish to discuss briefly two lesions of the female urethra in which radium treatment seems to be the method of choice. The first lesion, urethral caruncle, is common; while the second lesion, primary carcinoma of the urethra, is very rare.

A urethral caruncle may give rise to no symptoms and may be discovered only during a routine examination, or it may cause itching and burning or may give rise to intense pain on urination. Caruncle should be clearly distinguished from prolapse of the urethral mucosa, which is not suitable for radium treatment.

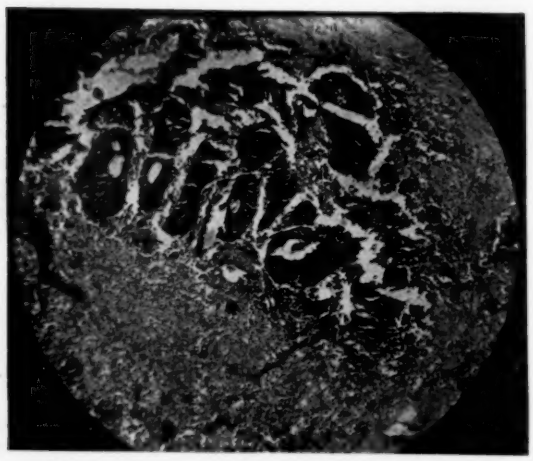

FIG. 1. Primary carcinoma of female urethra.

A true caruncle is a definite benign new growth, often a papilloma, so vascular that it may be confused with an angioma. The growth may be sessile or pedunculated, and generally springs from one portion of the circumference of the meatus. The sessile growths are especially difficult to remove completely with the knife and are apt to recur. One-half of the caruncles treated by us had previously recurred after other methods of treatment, some of them three or four times.

In contradistinction to caruncle, prolapse of the urethral mucosa practically surrounds the meatus. We do not consider these cases of prolapse suitable for radium treatment but believe they are best treated by an operation similar to the Whitehead operation for hemorrhoids. Graves[1] in his textbook says that the true caruncle is covered by squamous epithelium characteristic of the vestibule while the prolapsed urethral mucosa is covered by "modified epithelium characteristic of the urinary tract." He says that at times microscopic examination is necessary to distinguish the two lesions. However, from the viewpoint of treatment, the distinction is not so necessary, for a prolapse resembling a caruncle so closely should be suitable for radium treatment.

Our early patients were treated by surface applications of radium element and the later ones by the insertion of a well screened tube into the external meatus. By modifying our technique from time to time we have developed our present method which aims at the cure of the caruncle by one application of radium. The exact dosage is very difficult to estimate accurately. The same dose which produces considerable destruction of tissue in one patient will have but slight effect on the caruncle or normal tissue in another. Our technique of treatment is as follows:

1. Nitrous oxide anesthesia because of the exquisite local tenderness and to permit a thorough pelvic examination.

2. Excision of a small portion of the growth for microscopic examination.

3. Application of the electrocautery to the bleeding spot left by the excision of this small piece.

4. Application of screened radium to the urethral canal, 50 mg. of radium element screened with 0.5 mm. silver, 1 mm. brass and 1 mm. rubber, and the insertion of enough 5 mg. steel needles to occupy the growth and usually to surround the urethral canal. A sponge is placed over the meatus and the labia united over this by a removable suture passed through the outer end of the rubber covering the tube in the urethra. The radium is allowed to remain in position three to six hours, one treatment usually being sufficient. There is considerable local reaction after this

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treatment but this soon subsides, and we know of no recurrences where this dosage has been used.

We have not embedded unscreened emanation seeds in these cases but believe they are suitable where the caruncle is sufficiently large to protect, by its size, the neighboring portions of the vulva from the buried emanation.

Primary carcinoma of the female urethra is a rare disease but of sufficient importance to deserve some attention. In 1922 we[2] reported a tumor of this character following a caruncle which had been present for several years. At this time our case seemed to be the sixty-ninth on record but since then other cases have been reported by Venot and Parcelier,[3] Scholl and Braasch,[4] Shaw,[5] Culver and Forster,[6] and O'Conor.[7] We wish now to report one more case of this rare disease.

This patient was a married woman, aged sixty-two, who had never been pregnant. She complained of bleeding from a growth at the external meatus. The family history was negative for cancer. Her personal history was unimportant. Six months before our first examination she noticed a swelling in the region of the external meatus and began to have pain, burning and frequency of urination. There was occasionally some bleeding. She was treated at another hospital by radium and vesical irrigations, being told that the growth was not malignant. She came to us about three months after the last radium treatment, bleeding severely. There was a globular growth about 3 cm. in diameter at the superior portion of the external meatus. This growth was treated by the electrocautery, a portion being excised for microscopic examination. This was over one year ago and she has been free from symptoms and from any sign of recurrence since that time. A diagnosis of carcinoma was made in the pathological laboratory of St. John's Hospital.

Treatment of these urethral carcinomata is not satisfactory unless they can be diagnosed early. In certain of these early cases excision may be performed. In the far advanced case we believe that radium affords the best method of treatment of the local growth although palliation is all that can be hoped for in many cases. The regional lymphatics should be treated by roentgen radiation or by excision, unless the primary growth is so far advanced as to make the possibility of a cure very remote.

In conclusion, we wish to place special emphasis on the probable relationship between the irritation from urethral caruncle and the growth of urethral carcinoma.

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ABSTRACT OF DISCUSSION

Dr. Howard A. Kelly, Baltimore, Md. Dr. Pomeroy has drawn attention, very properly, to the fact that true urethral caruncle is not a very rare disease. It stands out in a sharp edge like a cock's comb, bleeds easily and is very tender. Why it is so tender no one knows. Reed of Glasgow thought this was due to nerve cells but that is not yet proved. The growth must be due to thickened mucosa of the urethra, and this must be differentiated from sarcoma and carcinoma.

As to treatment of malignancies, by all means use radium. Remember that there may be glandular involvement, that they are very apt to recur and they cannot be handled by surgery. Radium is very effective and should be used.

Touching the lesions which are not malignant, I have not had any experience with radium. Papilloma is so rare that I have not had a case for a long time, but I prefer beyond anything else the desiccation method of Dr. William Clark and Dr. George A. Wyeth.

Dr. Henry J. Ullmann, Santa Barbara, Calif. I noticed that Dr. Pomeroy spoke of 100 per cent variation in his dose, and would like to know how he tells whether to use three or six hours at the first application.

Dr. Pomeroy, (closing). Replying to Dr. Ullmann, that depends somewhat upon the size of the growth and the amount of radium used.

CONSERVATION OF NORMAL TISSUE AFTER TREATMENT WITH RADIUM

CASE REPORT

BY DOUGLASS W. MONTGOMERY, M.D., AND GEORGE D. CULVER, M.D.

SAN FRANCISCO, CALIFORNIA

THERE is no more wonderful development of therapeutics than the selective lethal action of the very fine undulations emanating from radium or from a roentgen tube, upon certain types of cells. The malignant cells of many epitheliomata, especially those situated on the nose or in the neighborhood of the eyes, are exceptionally sensitive to these undulations, and it is fortunate that they are so, as by their use the infiltrating cells may often be eliminated, and the normal tissue left *in situ*, thus reducing the scarring and deformity to a minimum. The following remarks relate to epithelioma of the wing of the nose.

Epithelioma of the wing of the nose is not nearly so frequent as in the neighboring naso-labial groove. Although essentially the same in nature and such close neighbors the outlook for treatment of epithelioma in these two localities is quite different. In epithelioma of the naso-labial groove the danger of the growth perforating into the mouth, and by breaking down, leaving an unsightly hole is negligible. In fact, even the scar that is left after treatment lies along the bottom of the groove, and tends to become almost unobservable. On the contrary, in epithelioma of the wing of the nose there is grave danger of a perforation into the nasal cavity, or of the whole wing melting down, or at any rate of healing with unsightly deformity. Any procedure that will obviate these disadvantages must evidently be of much importance. As previously indicated, treatment by roentgen rays or by the gamma rays of radium provides such a means.

As an illustrative case we cite that of a woman, aged fifty-three, who applied for treatment Nov. 9, 1921, for an epithelioma of the left ala nasi, which had appeared on the outer surface ten years previously. When we first saw the patient the growth had penetrated into the nasal cavity, and could be seen and felt there. Furthermore, when the little finger was introduced into the naris and pressed outwards the blanching due to the cancerous infiltration could be seen to involve the whole wing of the nose.

A heavy charge of radium, heavily screened (so as to entirely exclude the alpha corpuscles and to cut down the beta corpuscles to a minimum), was placed both in the naris and on the outer surface. On the outer surface a special radium plaque containing 24.23 mg. of radium element was employed. It is circular and exactly the size of a ten cent piece, and contains all the radium that the manufacturers could at that time incorporate in the glaze. It, therefore, is much stronger than the ordinary so-called normal plaque. This we screened with 1 mm. of lead and 2 mm. of rubber, placing it on the outer surface. A tube containing 25 mg. of radium element was employed in the naris, the radium salt of which was screened by the inner glass container and also by the 0.35 mm. of silver of the outer container, in addition to which we enveloped it in 1 mm. of lead and 2 mm. of rubber. The screening of both instruments was, therefore, about equal. These were held in place with adhesive plaster for 6½ hours on Nov. 10, for 4¾ hours on Nov. 11, and for 7 hours on Nov. 12; in all, for 18¼ hours. No other treatment was employed in this case.

The treatment, therefore, was finished on Nov. 12, and on Feb. 24, of the following year, we were able to note that the wing of the nose was intact, with almost no scarring or other deformity. The center of the site where the cancer had been was, however, paper thin, and transmitted light with startling clearness. The cancerous epithelium, being much more sensitive than normal tissue to the gamma rays, had disappeared, and the small amount of connective tissue, which had not been destroyed by the disease process, was sufficient to maintain the wing of the nose.

The case furnished a beautiful example of what might be termed interstitial therapy.

This case contrasted most favorably with the result of treatment with an arsenic paste employed by one of us several years ago. An elderly woman had a similar lesion, and the arsenic paste acted well as regards curing the cancer, but it destroyed all the tissue indiscriminately, and left a large and most disfiguring defect.

RADIUM TREATMENT OF TONSILS*

BY C. AUGUSTUS SIMPSON, M.D.

WASHINGTON, D. C.

THIS paper is based upon three years' experience in roentgen and radium therapy of enlarged and hypertrophied tonsils. In it I have considered the indications for such treatment, the most practical and satisfactory methods, and the results obtained.

In considering the indications for roentgen and radium treatment of tonsils, I am of the opinion that an enlarged and infected tonsil is, in a majority of instances, a surgical condition, especially in children. I am quite as positive that a hypertrophied and infected tonsil is not necessarily or unequivocally a surgical condition.

For years laryngologists have endeavored to devise a safe and efficient method of destroying the lymphatic tissue of the tonsil by caustics, cautery, fulguration and other methods. The action of these agents is not so selective as radium and roentgen rays, and besides they are exquisitely painful, which in a large measure renders them useless. No one who has had any experience in the therapeutic use of radium and roentgen rays can question the atrophic and destructive effect of either when applied directly to lymphatic tissue. If our results are questioned by some physicians it is due to their lack of knowledge of the subject and our inefficient methods and techniques, and not to the inefficiency of radiation in these cases when properly applied.

It is only necessary to study the medical reports and articles of specialists, and many are on record, to realize that today there is an incessant and growing demand from physicians for a safe, efficient and less painful method of destroying tonsils than is to be obtained through surgery. There are certain complications of surgical operation, such as severe and fatal hemorrhage, infections of the neck, lung abscesses, and fatal edema, that are foreign to the correct application of radium to tonsils. The loss of time and the hospitalization of the patient after a surgical operation may be a serious economic burden. In addition to this it is a recognized fact among skillful surgeons and laryngologists that the most ideal and complete tonsillectomy may be followed by regeneration of the tonsil. A number of my radium cases have had one tonsillectomy. Should the patient have a severe or serious cardiovascular lesion, nephritis, diabetes, tuberculosis, high blood pressure, hyperthyroidism, or hemophilia, a surgical operation is contraindicated. It is certainly not warranted today with our knowledge of the atrophying and destructive action of radium.

Discussion of Methods. I do not consider that atrophy and destruction of a tonsil have been "satisfactory" if a large mass of lymphatic tissue remains in the tonsillar fossa. Too often a reduction in the size and bacterial content of the tonsil has been the signal for the discharge of a patient. This explains in part the dissatisfaction of the laryngologist with the results of radiation treatment. If one will draw the anterior pillar forward and outward, at the same time making the patient gag, even a very small tonsil will be projected into the field of vision. In my experience, all the tonsils that have been treated by roentgen rays alone show on examination definite masses of lymphatic tissue in the tonsillar fossa. The results of such treatment do not compare favorably with the

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results following the application of radium directly on or into the tonsil. We must clear the fossa of lymphatic tissue if we hope to get deserved recognition from the laryngologists, and the best clinical and bacteriological results. The fact that a tonsil no longer gives a positive culture will not keep a patient from an operation in the presence of focal infections, a history of tonsillitis, and a fossa half filled with lymphatic tissue. To avoid this I am positive that we must employ radium directly to or into the tonsillar tissue. On the outer surface of the jaw, however, I fail to see where radium offers prospects of a better result than roentgen-ray treatment.

I have applied radium needles and metal covered radium plaques to the surface of the tonsil; both procedures are unsatisfactory. In my experience two needles, 12.5 mg. each, have to be held in position too long to be practical. A larger amount of radium in a glass or very thin aluminum capsule would obviate this disadvantage, but I believe that more reaction and discomfort following the treatment would be encountered. The plaque that I have employed since 1921 and which was made especially for this work, contains less than 30 mg. of radium, spread over a surface of 2 sq. cm. It is oval in shape with rounded edges, without corners and the window is covered with a rubber composition that filters out less than 2 per cent of beta rays. The advantage that this applicator has over needles and metal capsules is due to the fact that more beta rays than gamma rays reach the tonsil. Studies by Colwell and Russ, Chambers, Marshan, Bogg and others have amply proven the bactericidal action of beta rays. Hence we not only secure a reaction on each tonsil which produces a noticeable reduction in the size of the tonsil after each treatment, but in addition, a sufficient amount of beta radiation to have a marked inhibitory effect on bacterial colonies. The applicator, when applied unscrewed to the skin, gives a reaction following a 20-minute exposure.

I swab the tonsil with a 2 per cent cocain solution, attach the plaque to a compass-shaped tonsil hemostat which retains the open, unfiltered window of the plaque directly against the surface of the tonsil, and here it stays in position without the patient's help for 30 minutes for each tonsil. The oval shape allows the plaque to fit snugly between the pillars. A dental suction tube must be used to carry off the saliva. With this technique one gets a mild mucous membrane reaction on each tonsil. A slight blanching of the surface appears in one week, some local soreness follows, which seldom lasts more than three days, and at least 30 per cent of the patients fail to notice any local tenderness or pain. This treatment can be employed only in older children, my youngest being nine years, and adults. A sensitive throat may require the free use of a spray and swab of local anesthesia before the plaque can be adjusted. However, it is efficient, and one treatment will diminish the average tonsil as much as four or five applications of roentgen radiation. The largest tonsils have never required over four treatments at three-week intervals. The average case requires three treatments.

In adult patients with sensitive throats, in children, and in cases where quick results are desirable, I have been employing glass emanation seeds of varying strength. Intense reactions from using emanation seeds too strong, namely several seeds of ½ or 1 millicurie in each tonsil, implants too near the pillars, impatience for results, and too frequent treatments almost caused me to discard this method at first. There were some very sore throats, intense ear aches, exaggerated arthritides and eczemas, flaring up of erythema multiforme and explosive purpuras. I have learned from experience that while ½ or 1 millicurie seeds secure quick and pronounced atrophy, the accompanying reaction and pain make their use impractical. I now employ emanation seeds of not over ¼ millicurie in strength. The number to be implanted in each tonsil depends on its surface extent and size.

As in the preparation for the use of radium plaques, I paint each tonsil with a 2 per cent cocain solution and have the patient gag. For buried tonsils, traction on the anterior pillar with a flat blunt instrument gives one an idea how much lymphoid tissue is to be destroyed. The

average sized tonsil can easily hold two seeds. Extreme care should be exercised not to have either seed nearer a pillar than 0.5 cm. and the same distance should separate each of the two to four seeds. Should the tonsil be unusually large and protruding, three or even four seeds, ¼ millicurie each, can be used with entire safety and with assurance that the reaction will not be too severe.

A curved-tip trocar is used to insert the seeds. It is important to withdraw the trocar slightly before the stylet pushes home the seed, in order to retain the seed in position.

Care should be taken to avoid crypts and spaces in the tonsil when inserting the trocar, because to deposit a seed in a good-sized crypt is practically to lose the effect of that particular seed. This means waiting two or three weeks before another seed can be used in this location with safety. At the end of three to five days the tonsil swells, becomes red and tender, and shows two or three small, white blanched areas, the size of a wheat seed. The patient may have slight ear ache for a couple of days and some complain of what they consider an ordinary sore throat for three or four days. This sore throat is somewhat more severe than that following ½ hour application of the oval plaque. It does not differ from an ordinary sore throat, and does not prevent the patient from eating or attending to his daily duties. At the end of eight or ten days the tonsil becomes pale and a decrease in size is noted. This shrinkage progresses during the following two weeks, at the end of which time not a vestige of a previously protruding tonsil may be seen. Close adherence to this technique will produce the most complete atrophy and destruction of tonsillar tissue. In many cases one treatment causes the tonsil to vanish. Sometimes by pulling the anterior pillar forward and outward at the end of one month one may discover a tag of tonsil which has escaped the effects of the radium. One ¼ millicurie seed implanted in the apex of such a tag will be all that is necessary to destroy it.

Repeating a treatment too soon is as harmful as having the seeds too strong or depositing one in a pillar, and has all the disadvantages of a careless roentgen-ray technique or even more, as the mucous membrane is much more sensitive to both radium and roentgen rays than the skin. I believe the implied and predicted dangers of such small amounts of radium as two ¼ millicurie seeds in the tonsil may be discounted. I have never seen the slightest bad effect, early or late. I have treated several epitheliomas of the base of the tongue and the tonsil where not one, but several one millicurie seeds were inserted in an area not larger than a good sized tonsil, with no bad effect. At the present time I have a patient with a lympho-sarcoma of the tonsil in which I have inserted five one millicurie seeds. This constitutes a dose of ten times the intensity as that employed in a tonsil. The patient did have a sore throat for several days, but not the slightest bad effect, and both tumor and tonsil vanished with one treatment.

As to the number of treatments necessary, is it as easy to eliminate the infiltration of a carbuncle as it is to get rid of the induration of a small furuncle, or is it as easy to destroy a large infiltrating epithelioma as a small, thin one, or atrophy a large fibroid as quickly as a small one, in all cases using the same strength of either roentgen rays or radium? It is quite as intelligent to expect the same dose of radium to atrophy all the varying sized tonsils in the same number of treatments. Even the two tonsils of the same individual vary, not only in size but in their fibrous content. In addition to this I have noticed what seems to me to be a varying radio-sensitiveness of the lymphatic tissue of the tonsils. This is not always entirely dependent on the relative fibrosis of the tissue, so much as on the history of previous attacks of tonsillitis and apparent bacterial contamination of the tissue. Hence we should be wary in saying how many treatments will be required in each individual case. We do know that there is not a tonsil that will not become atrophied and destroyed by radium correctly used. If one application of properly placed emanation seeds will not do the work and clear the fossa of all lymphatic tissue, two

or possibly three treatments will. It will do this invariably and constantly.

Radium atrophy of tonsils constitutes a real advance in medicine. It is indicated in a class of patients who, because of constitutional defects and lesions, should not be subjected to the risks, pain and prostration of an operation.

DISCUSSION

Dr. Henry K. Pancoast, Philadelphia. It is a foregone conclusion that all of us will have to treat enlarged tonsils from now on whether we wish to do so or not, because there are so many cases in which tonsillectomy is indicated that cannot be operated upon, for the reasons Dr. Simpson has given. These are the only cases we ever treat. Where there are no contraindications, I feel that tonsillectomy is the procedure of choice, although I would prefer the use of radium on my own tonsils. In our technique we employ two 25 mgm. tubes in brass containers for cross-fire effect, and placed against the tonsil in a modified tonsil clamp. We have used bare tubes, especially to remove the last vestige of the gland. My preference is for radium in direct connection with the tonsils. In cases where there are very large tonsils I have supplemented this with bare tubes, but never more than one-half millicurie, and I think Dr. Simpson is correct in saying that one-fourth millicurie is better. The reaction is not excessive. The patient complains of sore throat for a few days. In only one case have we had to use the supplementary bare tubes. I must say that radium inside is far preferable to roentgen rays outside. It requires a much shorter time and we do not have the dryness of the throat which is so often associated with external radiation.

Dr. T. D. Quigley, Omaha, Nebraska. I wish to say that the first man to suggest radium or roentgen-ray treatment for tonsils was Dr. William Ross of Omaha, Nebraska, but he is not given credit for this. It seems to me that if we use 100 mgm. of radium at the angle of the jaw, we get just as much irradiation as if we used the seeds, and with less discomfort. I have had personal experience with this. I had severe tonsillitis and used 100 mgm. outside at the angle of the jaw for about thirty minutes and following that had no tonsillitis for three years. Another attack came on then and I repeated the treatment with 100 mgm. at each side of the angle of the jaw and think I am cured. Having had this experience myself, I believe it is a good and sufficient treatment.

Dr. C. Augustus Simpson (closing). I think it has been pretty definitely proven that the *beta* rays have a decided bactericidal action, and that the bare emanation seeds in addition have a local caustic effect on the tissues in which they are embedded. These two separate and distinct results from radium therapy are in addition to its well-known atrophying effects on lymphatic tissue. The absence of both the caustic effect and the direct bactericidal action in the case of roentgen rays applied externally probably accounts for the greater efficiency of direct radium applications to and into the tonsil.

THE END RESULTS OF THE TREATMENT OF CARCINOMA OF THE BREAST WITH SURGERY, RADIUM AND ROENTGEN RAYS*

BY HENRY SCHMITZ, M.D.

CHICAGO, ILLINOIS

FROM 1914 to 1921, inclusive, 281 cases of microscopically diagnosed carcinomata of the mammary gland were treated with surgery, radium and roentgen rays in my services at the Mercy and Augustana Hospitals in Chicago; 124 were primary carcinomata and 157 had recurred either after a radical amputation or a simple mammectomy or an excision of the tumor. Two cases occurred in men. Of the 279 cases seen in women, 61, or 21.5 per cent, were observed in nullipara and 218, or 78.4 per cent, in uni- or multipara. As the percentage of nulliparous women of cancer age is 18.25 we may state that the frequency of the disease is the same in the two classes in our series. The age incidence also appears to be the same in this series as in carcinomata of other organs; 75, or 30 per cent, appeared during the fifth decade and 83, or 33.2 per cent, during the sixth decade. Therefore almost two-thirds of the cases occurred between the 41st and 60th year of life. This incidence is the same as observed in carcinomata of the uterine cervix, in which about 67 per cent are observed during the fifth and sixth decades of life. See Table 1.

INDICATIONS FOR TREATMENT

The mammary cancers in this series were treated either with surgery, or with radium, roentgen rays and surgery, or with radium and roentgen rays, or palliatively. The indications for these four methods were based on a grouping of the cases. The carcinomata were divided into two classes: A, primary; and B, recurrent.

In the primary mammary cancers we determine by a careful physical examination the extent of the disease, the relation of the growth to the adjacent tissues, the location and character of the lymph node involvement and by roentgen examination the metastatic invasion of the thoracic organs and the skeleton. The clinical findings enable us to group the cases, and the grouping determines the method of treatment.

The recurrences followed either a radical breast amputation, a simple mammectomy or an excision of the growth in the breast. They were also subjected to the same procedure of physical examination. The indications for treatment are based on the grouping. See Table II.

TECHNIQUE OF TREATMENT

The Stewart or Rodman incisions were used in the surgical treatment. The axilla is laid wide open and cleared of all glandular tissue and fat. The pectoralis muscle is removed with the breast in one mass. If we decide to leave it then the superior and inferior fasciae and the glands beneath the muscle are thoroughly removed. Should the growth be located near the skin or have involved the skin then the latter is widely removed and the incision is made with the thermocautery. The defect in the skin is covered with Thiersch's grafts. Should doubt exist that gland involvement might be present, or the microscope reveal glandular invasion, then roentgen rays and radium are applied as soon as the patient has passed the effects of the operation. If convalescence is uncomplicated the patient is discharged within eight to ten days after the operation.

The factors employed in the application of roentgen rays are as follows: The fields number four. One field includes the shoulder and neck. The head of the patient is turned to the opposite side during the application of the rays to this field to expose the neck in its entirety. The second and third fields are 12 to 15 cm. wide by 15 cm. long and cover the entire sternum, infected breast and axillary region. The nipple line separates these fields. During the treatment of the outer field the chest is raised 5 to 8 cm. to expose the axilla and side of thorax as much as possible. The fourth field is 20 to 25 cm. square

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and comprises the posterior chest wall and shoulder. The roentgen rays for the anterior fields are produced with a 140 kv. maximum current, a focus skin distance of 50 cm. and a filter of 0.1 mm. Cu plus 1.0 mm. Al. Should the breast be very large and the soft tissues of the chest wall very thick then a 0.2 mm. Cu plus 1.0 mm. Al filter is used. The duration of application is 200 ma-min. with the 0.1 mm. Cu filter and 350 ma-min. with the 0.2 Cu filter. The factors for the posterior field are 200 kv. maximum current, 50 cm. focus skin distance, 1.0 mm. Cu plus 1.0 mm. Al filter and 600 ma-min.

The skin reactions obtained by these rays are characterized by an intense erythema and peeling of the superficial layers of the epidermis. A deep tanning or browning appears within six weeks.

The roentgen radiation absorbed by the tissues does not suffice to degenerate or

TABLE I

AGE AND PREGNANCY IN CARCINOMATA OF THE BREAST

AGE

Age	21 to 30	31 to 40	41 to 45	46 to 50	51 to 55	56 to 60	61 to 70	71+
Number	6	42	38	37	49	34	26	18
Per cent	2.4	16.8	15.2	14.8	19.6	13.6	10.4	7.2
			158 = 63.2 per cent					
Cancer of cervix	4.2	18.2	15.0	20.0	21.5	11.7	8.9	1.9

PREGNANCY

Nullipara 61 or 21.6 Per Cent; Uni- or Multipara 218 or 78.4 Per Cent.

TABLE II

THE GROUPING AND METHODS OF TREATMENT OF CARCINOMATA OF BREAST

Group	Physical Findings	Method of Treatment
	A—Primary Carcinomata	
I	Single movable growth	Radical amputation
II	Multiple movable growths, axillary gland involvement or both	Roentgen rays, radium and radical amputation
III	Fixation to chest wall or axilla or supraclavicular gland involvement	Roentgen rays and radium
IV	Invasion of chest wall, mediastinum or skeleton	Palliative treatment
	B—Recurrent Carcinomata	
I	Local but freely movable	Roentgen rays, radium, excision
II	Axillary but freely movable	Roentgen rays, radium, excision
III	Fixation to skin, chest wall, or axilla or supraclavicular gland involvement	Roentgen rays and radium
IV	Metastases in lungs, mediastinum bones, etc	Palliative treatment

TABLE III

THE GROUPING OF 281 CARCINOMATA OF THE BREAST ACCORDING TO YEARS. THE 5- AND 3-YEAR CURES IN PARENTHESES

	A—Primary					B—Recurrent					
Group	I	II	III	IV	Total	I	II	III	IV	Total	Grand Total
Year											
1914	.....	.....	.....	2	2	1	1	2	2	6	8
1915	.....	.....	.....	2	2	.....	2(2)	1	4	7(2)	9(2)
1916	2(1)	3(2)	3(1)	3	11(4)	3(2)	4(1)	7	6	20(3)	31(7)
1917	2(1)	1(1)	1	1	5(2)	2(1)	1	3	5	11(1)	16(3)
1918	1(1)	6(2)	3	1	11(3)	3(3)	1	10(2)	2	16(5)	27(8)
1919	2(2)	2(1)	7(1)	3	14(4)	1	4(1)	4	4	13(1)	27(5)
1920	.....	.....	1	1	2	1(1)	1(1)	4	3	9(2)	11(2)
1921	3	3	4	1	11	2	.....	5	9	16	27
1922	4	3	17	4	28	11	5	11	11	38	66
1923	7	16	10	5	38	1	3	10	7	21	59
Total	21	34	46	23	124	25	22	57	53	157	281

TABLE IIIA

THE THREE-YEAR END RESULTS IN MAMMARY CARCINOMA

A—Primary B—Recurrent

Group	I		II		III		IV		Total		I		II		III		IV		Total		Grand Total		
	No.	Living	No.	Living	No.	Living	No.	Living	No.	Living	No.	Living	No.	Living	No.	Living	No.	Living	No.	Living	No.	Living	Per Cent
Year																							
1914	..	..	..	..	..	..	2	0	2	0	1	0	1	0	2	0	2	0	6	0	8	0	
1915	..	..	..	..	..	..	2	0	2	0	..	..	2	2	1	0	4	0	7	2	9	2	
1916	2	1	3	2	3	1	3	0	11	4	3	2	4	1	7	0	6	0	20	3	31	7	
1917	2	1	1	1	1	0	1	0	5	2	2	1	1	0	3	0	5	0	11	1	16	3	
1918	1	1	6	2	3	0	1	0	11	3	3	3	1	0	10	2	2	0	16	5	27	8	
1919	2	2	2	1	7	1	3	0	14	4	1	0	4	1	4	0	4	0	13	1	27	5	
1920	..	..	..	..	1	0	1	0	2	0	1	1	1	1	4	0	3	0	9	2	11	2	
Total	7	5	12	6	15	2	14	0	47	13	11	7	14	5	31	2	26	0	82	14	120	27	20.8
Per cent		71.5		50		13.3				27.8		63.5		35.7		6.5				17.1			

Primary 47, Living 13, Per Cent 27.6. Groups I and II 19, Living 11 = 58 Per Cent.
Recurrent 82, Living 14, Per Cent 17.1. Groups I and II 25, Living 12 = 48 Per Cent.
Total Primary and Recurrent Groups I and II 44, Living 23, Per Cent 52
Total Primary and Recurrent Groups I and III 41, Living 4, Per Cent 9.8.

TABLE IV

COMPARATIVE VALUES OF OTHER CLINICS AND METHODS—FIVE-YEAR RESULTS

Clinic	Method of Treatment	Group I Per Cent	Group II Per Cent	Group III Per Cent
König	Surgery	100.0	39.0	None
Krönig	Radium	21.4	16.6	11.0
Schmitz	Surgery, radium and roentgen rays	64.5	42.0	10.0

destroy the tumor cells permanently. Therefore radium rays are added. The radium is applied either in packs or in needles. The pack is 6 × 10 cm. in size and 3 cm. in thickness. The amount of radium used is either 200 or 400 mg. element filtered through 1.5 mm. brass. The time duration of application is 14 hours with the 200 mg. pack and 7 hours with the 400 mg. pack. The latter is used only where the soft tissues of the chest wall and the breast are very thin, that is from 1 to 3 cm. In large breasts and heavy chest walls we prefer needling, using a 10 mg. element needle for 8 to 10 hours to each square centimeter of surface. The "needling" is begun at the periphery, encircling the growth in the healthy tissue. The next circle is placed 1 cm. interiorly to the first, and so on. Finally we proceed along the pectoralis major muscle, placing the needles between it and the chest wall, and then enter the axilla. The arm is extended upward and protected with lead plates during the radium treatment.

The combined use of radium pack and roentgen rays produces destruction of the skin. The local application of Dodd's lotion mornings and evenings conceals the condition of the skin from the patient, relieves the subjective symptoms and hastens the reparative process.

In the primary Group II and the recurrent Groups I and II cases, the roentgen rays are applied first. From three to four days is the usual time consumed. The operation follows the next day. Should the patient exhibit marked radiation sickness, then the operation is postponed until the termination of the systemic reaction. The radium pack is applied to the supraclavicular and axillary regions and chest when convalescence from the operation is complete.

THE FIVE- AND THREE-YEAR RESULTS

The cases of mammary cancers that entered my clinic from 1914 to 1923, inclusive, were grouped and tabled. See Table III.

The number of patients in each year and group subjectively and anatomically well for three years or more are placed in parentheses. Up to and including 1918 there were 91 primary and recurrent cases with a five-year absolute curability of 20, that is, 22 per cent; and up to and including 1920 there were 129 cases with 27 three-year cures, or 20.0 per cent. We made the observation that patients treated according to our method, in whom the cancer recurred, would have the recurrence and die from cancer before the end of three years. There has been only one exception, the patient succumbing 37 months after admission to the clinic. Of 47 patients with primary cancers, 13, or 27.6 per cent, passed the three-year period well and free from recurrence. Of 82 recurrent cancers, 14, or 17.1 per cent, passed the three-year period well and free from the disease. The number of primary cases of Groups I and II that passed the five-year period is 15 with 8 absolute cures, or 53.2 per cent. The number of recurrent cancers of Groups I and II that passed the five-year period is 18 with 9 absolute cures, or 50 per cent. The two groups of primary and recurrent cancers are the operable cases. They total 33 cases with 17 five-year cures, or 51.5 per cent relative curability. The five-year cures in Group III, that is, the clearly inoperable cases, are primary 7 with 1 cure, or 14.3 per cent, and recurrent 23 with 2 cures, or 8.7 per cent—or a total of 30 in both classes with 3 cures, or 10.0 per cent. The three-year results are shown in Table IIIa.

DISCUSSION

To evaluate the therapeutic efficacy of our method of treatment of mammary carcinomata we must compare the results with those obtained in other clinics. Statistics based on a grouping of the cases are obtained with difficulty. Table IV, however, permits of comparison.

Groups II and III indicate the superiority of the combined treatment of surgery, radium and roentgen rays over the purely surgical or the radium methods. Every case that entered the clinic is included in our statistics, whether the patient was treated, refused to complete the treatment, was hopeless from any standpoint of treatment or the record was incomplete because we could not follow the case to its final termination.

The early recognition of a lump in the breast, the immediate application of the indicated treatment and the careful microscopic study of the removed tissues for diagnosis and prognosis will improve the absolute curability percentage of cancer of the breast. Patients in Group I have a 7 in 10 chance for a permanent cure, in Group II a 4 in 10, in Group III a 1 in 10, and in Group IV none.

SUMMARY

1. Carcinomata of the breast must be grouped to determine the proper method of treatment and to evaluate the efficacy of the various methods of treatment.

2. The methods of treatment indicated in each group are given and their curative value is shown in the three-and five-year end results.

3. The percentages of the curability of the three-and five-year end results do not differ materially. This conforms to the observation made that patients with carcinoma of the breast succumb almost invariably to a recurrence during the first three years following the treatment.

4. The statistics indicate the superiority of the combined method of surgery, radium and roentgen rays over the purely surgical or radiological methods of treatment.

DISCUSSION

DR. HOWARD A. KELLY, Baltimore, Maryland. I am sorry that I cannot present statistics. I am glad to say that we are getting better cases now than when we had only the refuse. We now examine every case by the roentgen ray first to determine if there are any metastases in the chest. You will be surprised sometimes in what you consider an early case to find a well advanced nodule in the chest and know that surgery will be hopeless.

In any case which we consider operable we give surgery the preference. It is not an operable case in which we find nodules in the

neck. These we have extirpated and treated occasionally with success, but only occasionally, for usually the disease has gone far beyond the neck.

We treat the inoperable cases and the recurrent cases with radium. Of course, they must be watched and treated over a long period of time. One of the most striking cases I saw a good many years ago. I had told Dr. Halstead of our work and he said, "Would it not be fine to get rid of all inoperable cases in surgery?" He sent us a case with a big, brawny, frozen breast that was involved down to the ribs, and with axillary involvement. We went to work and by good luck the growth melted away. The patient was not cured, but nothing of the kind had been seen before that. We have had this happen many times since, getting a somewhat prolonged temporary result.

The effect of irradiation upon metastatic bone lesions is both startling and gratifying.

Dr. George E. Pfahler, Philadelphia. I have been much interested in the treatment of carcinoma of the breast from the very beginning, and in fact, I treated my first case of carcinoma of the breast in 1900. It was a recurrent case and the patient was still alive ten years afterward. I do not know whether or not she is still alive for I have lost track of her. I am going to get together the complete statistics of all my cases over this long period of time so as to present to you what has been accomplished by the various techniques employed.

I wish to emphasize what Dr. Kelly has said and what I have been carrying out for ten or fifteen years, and that is a roentgen ray examination of every case of carcinoma of the breast. Once in a while you will find metastases in the spine in cases that you think are relatively early. That is why surgeons so often fail in cases they think should get well, because the metastases have so far exceeded anything they expected.

In the treatment of carcinoma of the breast, radium occupies a place second to the roentgen ray, at least in the hands of the average man who is using radium, because most of us have a comparatively small amount. Dr. Kelly and the Memorial Hospital have sufficient radium and they can treat large areas, but my feeling is that radium should be used where it can be brought into contact with, or inserted into, the diseased tissue, but where we have to treat large areas we can accomplish more with the roentgen ray. I have had a great deal of experience but must confess that it is not clear in my mind just how every case should be treated, for we have seen excellent results with massive treatment, with fractional treatment, with low voltage, and with high voltage treatment. I am inclined to think that when we once master the high voltage rays, we will treat most of the cases of carcinoma, whether metastatic, primary, or recurrent, with high voltage. I am not prepared to do this today but this is based upon my experience, not based upon five-year statistics. When a massive carcinoma is seen to shrink up and disappear, and when metastatic nodules disappear and remain away as long as eighteen years, we must feel that we have a power that is useful if we learn how to use it. I think we must treat the cases sufficiently to destroy the cancer cells and preserve the healthy cells.

In this connection I wish to repeat what has been said before, that we must not forget the very valuable lung structure beneath the breast which must be taken care of, and when treating the mediastinal glands, we must remember that we have in the mediastinum the heart and blood vessels which are filled with a great mass of blood, so that we are irradiating every blood corpuscle in the body, and we must not lose sight of the effect that roentgen rays have on the blood and on the vessels. I do not know how to avoid it absolutely, but we must keep it in mind in every case. Let us not irradiate these tissues any more than we absolutely must.

Dr. Burton J. Lee, New York City. I wish to express my appreciation of Dr. Schmitz's paper, which is carefully drawn up and most interesting. I have a little different angle on this subject, possibly, from most of the men here. It has been my privilege as a breast surgeon to see many cases of carcinoma, and in increasing numbers during the past few years, at the Memorial Hospital Breast Clinic. I have prophesied for several years that if the figures were carefully drawn up it would be found that about 15 per cent of the cases were living at the end of five years. That is the lowest figure that has ever been advanced, and during the last year I went over all the cases of my own and my colleagues at the Surgical Clinic from April, 1914 to 1919, and these were reported in April, 1924, just five years from the time the last case was operated upon. We found exactly 15 per cent living. No patient was living who had axillary nodes at the time of operation. Therefore, I cannot agree with Bloodgood or with König that we get 100 per cent cures in carcinoma of the breast. I think the situation is much more serious and dark.

I think that surgery has been the routine procedure, but I think we have not all appreciated how poor the statistics are. In going over the figures from other clinics I found they varied from 22 to 46 per cent. I think in many instances you will find cases which pathologi-

cally are mastitis with undue proliferation. We have cases brought in repeatedly at the Memorial Hospital in which we find no cancer, but chronic mastitis with epithelial proliferation.

To show what pathologists are doing throughout the country, at one hospital we had 5 cases with marked recurrence, and the pathological report returned was "fibroma." Therefore, I believe many statistics are erroneous and that there are many cases that do not belong in the carcinoma group at all. Furthermore, it is only in the last ten years that cases have been followed up properly and I feel that it is hardly fair to the patients to tell them that if operation is done a sure cure will result. That is not the truth. We feel that we must get exceedingly early cases in order to get satisfactory operative results, and even then the percentage of cures will be low.

Dr. Bernard F. Schreiner, Buffalo, New York. I am unable to quote any definite statistics. We have followed a procedure similar to that of Dr. Schmitz. The early primary cases are perhaps handled a little differently, but we have insisted on radiation and operation. We recognize four or five groups of cases. First of all, the perfectly movable nodule in the breast for which we use one series of hard roentgen-ray treatments and operation. In another we have deliberately implanted and used radium packs of the new type with increased depth dosage. Tumors of the breast with movable nodule we have treated conservatively by implantation, with high power roentgen rays. Of course, we have paid particular attention to mediastinal involvement and it is surprising how often we find a small nodule in the breast with definite metastasis of the chest.

It occurred to me in looking over some of our work recently that tumors in the inner half of the breast have a tendency to metastasize to the mediastinum more than those in the outer side.

DILATATION OF DIPLOIC VEINS AND OTHER ANATOMICAL VARIATIONS IN THE SKULL*

BY LEON T. LEWALD, M.D.

Professor of Roentgenology, New York University and Bellevue Hospital Medical College

NEW YORK CITY

IN view of the general impression held by roentgenologists and neurologic surgeons as to the importance of prominent diploic veins, it appears advisable to call attention to the relative frequency of prominent or dilated diploic veins in individuals who are not suffering from any demonstrable intracranial lesion.

Inasmuch as the writer has also encountered cases of markedly increased cerebral depressions not associated with active intracranial lesions, it has appeared advisable to include these cases (Figs. 11 and 12) together with the cases of dilated diploic veins, as both signs are regarded as of great significance, and misinterpretation of the value of either of these findings may lead to serious error in diagnosis and even to unnecessary surgical procedures (Fig. 10).

For instance, a patient suffered extreme mental anxiety for a period of several months following a roentgen examination because of an erroneous diagnosis of an intracranial lesion. The patient had simply an anomalous development of his diploic veins (Figs. 3, 4, and 5).

In a recent article[1] on this subject the following statements are made:

"Roentgenograms of the skull present many variations in the size and number of the vascular markings. The venous sinuses, the meningeal vessels and the veins of the diploe may all be visible as more or less distinct dark lines, and needless to say, the better the roentgenogram the clearer the vascular markings are visible. When the calvarium is thin—and this is a point worth noting—the normal vascular channels will often be seen so much better than when the skull is thick, that they may be mistaken for enlargements.

"In the attempt to arrive at a conclusion as to what is normal and what is pathologic, the personal equation of the examiner must play an important part. The roentgenologist, so frequently without a knowledge of the neurologic problems in the individual case, cannot be expected to correlate finer roentgen-ray changes with clinical symptoms. It is a weakness in roentgen-ray diagnosis, and one which will surely be overcome in the future, that roentgen-ray interpretation in a general hospital is so often left to the roentgenologist who is too busy with roentgenograms of bones, of the gastro-intestinal tract, of the chest, etc., to devote the

[1] Elsberg, Chas., and Schwartz, Chas. Increased cranial vascularity in its relation to intracranial disease. *Arch. Neurol. & Psychiatry*, March, 1924, xi, 292–306.

* Read at the Twenty-fifth Annual Meeting of the American Roentgen Ray Society, Swampscott, Mass., Sept. 3–6, 1924.

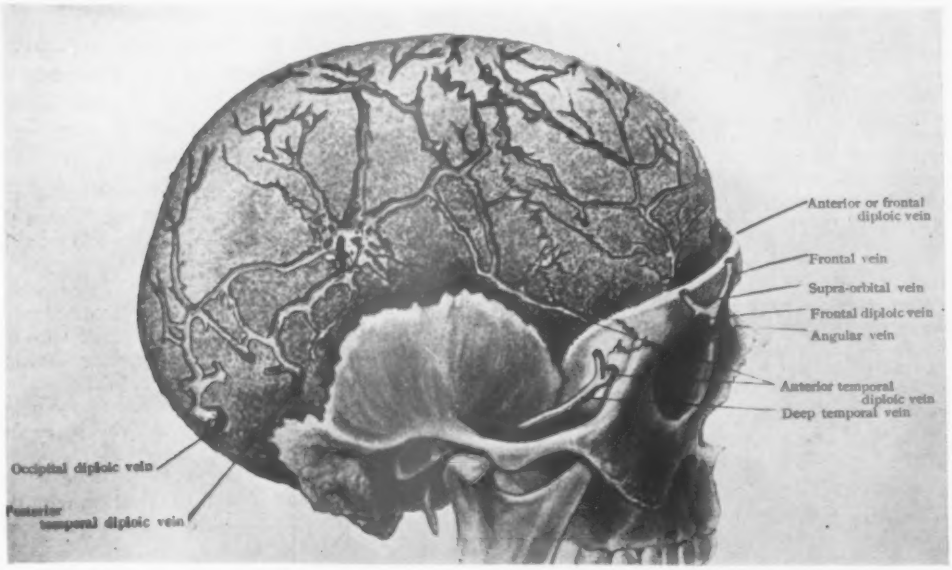

FIG. 1. Diploic veins (Piersol). Note the stellate appearance in the posterior temporal region. For similar appearance in roentgenogram, see Figure 8. Note the higher position of the stellate appearance in the roentgenogram, which is more accurate than the drawing. Cushing has also called attention to this fact.

FIG. 2. Diploic veins (Spaltcholz). Note the pattern differs from that shown in Figure 1 (Piersol). For similar appearance in roentgenogram see Figure 3. Numerous variations from both patterns are frequently encountered and the pattern is not always the same on both sides (Figs. 3 and 4).

necessary time and study to the neurologic significance of changes he observes on his films or plates. Probably, if he could be supplied with more clinical data, he would be in a better and fairer position to give a comprehensive report.

"Obviously, one must have a knowledge of the appearance of the normal skull in order to appreciate finer variations. A study of the vascular markings seen on roentgenograms of the skull, from the view point of what is normal, and from what should occur when the cranial and intracranial venous circulation is interfered with either locally or generally, should yield facts of interest. If such facts could be correlated with the symptoms and the signs of intracranial disease and with the lesions found at operation or necropsy, abnormalities in the size and number of the vascular channels should gain diagnostic importance. Schuller, Heurer and Dandy, and a few others have mentioned the fact that roentgen-ray evidence of enlargement of the vascular channels in the cranial bones was of diagnostic importance, but their publications did not go into detail nor did they study the separate vessels."

And the authors give the following conclusions:

"We have not found unilateral enlarged diploic veins in any other of the many gliomas that have been verified by operation or necropsy. Nor have we found unilateral enlargement of venous channels in metastatic tumors of the skull or brain.

"We have therefore arrived at the conclusion that if the diagnosis of brain tumor has been made, and unilateral enlarged diploic channels are found in the general area in which the tumor is suspected, there is considerable probability that the new growth is an endothelioma."

From a review of the literature one is apt to infer that dilated diploic veins, if *unilateral* and associated with definite signs of a brain tumor, are of great significance in determining the site of the lesion and the probability that the growth is an endothelioma. We wish to call attention, however, to the presence of unilaterally dilated diploic veins *not* associated with brain tumor or other demonstrable intracranial lesion, and report several cases of this nature encountered in routine head examinations for sinus disease or other lesions, such as fracture of the skull, or mastoiditis. We believe, therefore, that great care must be exercised in estimating the value of this roentgen finding in any given case, and unless roentgenograms after an interval distinctly show an increase of the diploic channels, no importance should be attached to the presence of either unilateral or bilateral dilatation of the diploic channels. In making a statement in regard to the question as to unilateral or bilateral dilatation we have found that even stereoscopic examination of *one* side is not sufficient to determine this question. Stereoscopic roentgenograms of *each* side are necessary, and additional help can sometimes be obtained by postero-anterior exposures which may clearly show dilated diploic veins in the frontal region, either on one or on both sides.

FIG. 3. Prominent diploic channels *not* associated with intracranial disease. Right side.

FIG. 4. Prominent diploic channels *not* associated with intracranial disease. Left side. Note the difference in the pattern on the two sides.

There appear to be two normal patterns of the diploic channels. According to one anatomist (Piersol) there is a stellate appearance in the parietal region with a continuation of one branch into the poste-

rior temporal and finally communicating with the lateral sinus through the mastoid emissary vein (Fig. 1). According to another anatomist (Spalteholz) this stellate appearance is lacking, one large channel with one small channel running backwards

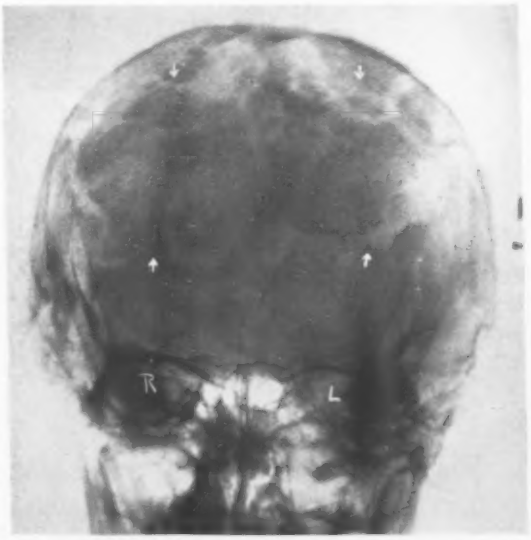

FIG. 5. Dilated diploic channels, anterior projection. Note the marked difference of the size and shape of the channels on the two sides (also see Figs. 3 and 4).

almost to the lambdoid suture before it courses downwards and forward to empty into the mastoid emissary vein (Fig. 2). Both anatomists describe an anterior or frontal, an anterior temporal, a posterior temporal, and an occipital, diploic vein on each side. We have been able to confirm these distinctions roentgenographically (Figs. 6, 7, 8, 9 and 10). Spalteholz also describes a parietal emissary and an occipital emissary vein. We have not been able to demonstrate these emissary veins roentgenographically. Furthermore, we could state that only rarely can the entire

FIG. 6. Unilateral prominent diploic channels not associated with intracranial disease. Note the similarity to the anatomical drawing (Fig. 2).

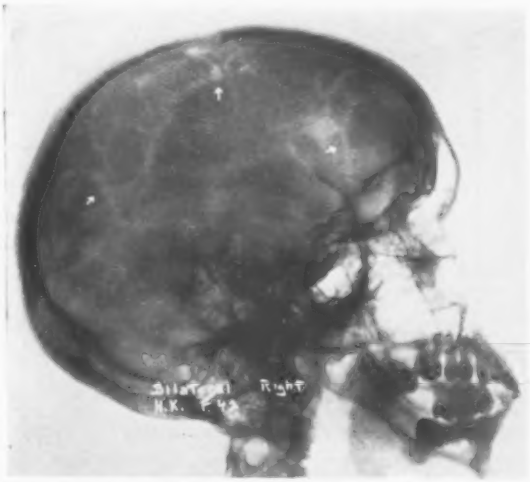

FIG. 7. Dilated diploic channels in a patient free from intracranial disease. The pattern corresponds somewhat to the anatomical drawing in Figure 2.

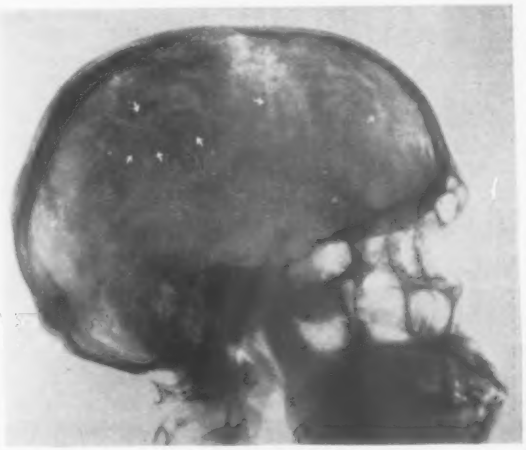

FIG. 8. Prominent diploic spaces without intracranial lesion. Compare with diagram (Fig. 1). Note higher position of stellate arrangement.

diploic system be traced in one individual; and in no two individuals have we encountered exactly the same pattern. The linear pattern of Spalteholz is more frequently encountered than the stellate pattern of

Piersol, and where the pattern can be made out on both sides, the two sides usually differ (Figs. 3, 4 and 5).

Some other anatomical variations in the skull have also been inserted in the descriptions of the cases reported, namely; depressions for the Pacchionian bodies producing peculiar areas of thinness in the skull. In one instance at least, a misinterpretation of this anomaly together with certain clinical symptoms led to the placing of a patient in a state hospital for the insane for observation and treatment. In another instance these thin areas have been interpreted as resulting from disease, especially syphilis.

It is also a well-known fact that in homicidal cases advantage is often taken of these cranial anomalies to bolster up a plea of mental aberration and in more than one instance an acknowledged crime has been excused on these findings.

In one instance a diagnosis of multiple fractures of the skull was made from no

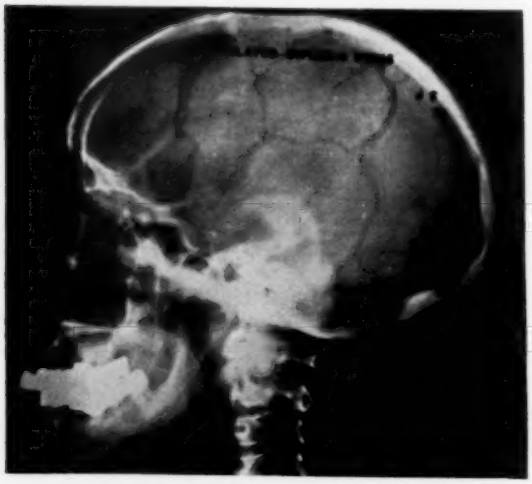

FIG. 9. Prominent diploic channels, atypical. No intracranial disease.

FIG. 10. Unilateral localized prominent diploic channels, not associated with intracranial disease, as determined by exploratory craniotomy.

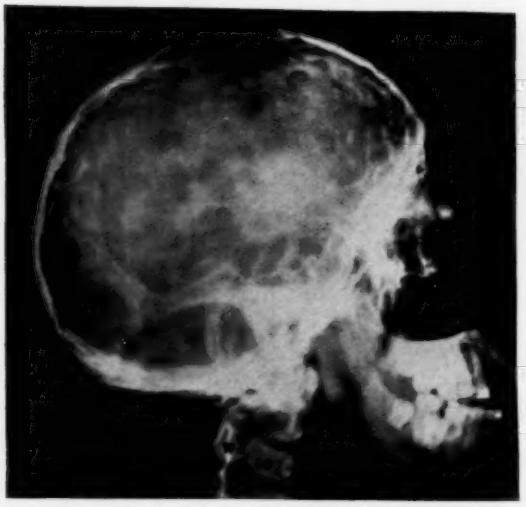

FIG. 11. Prominent convolutional markings. This remarkable appearance was observed in a boy aged sixteen, who showed no evidence of any active intracranial lesion.

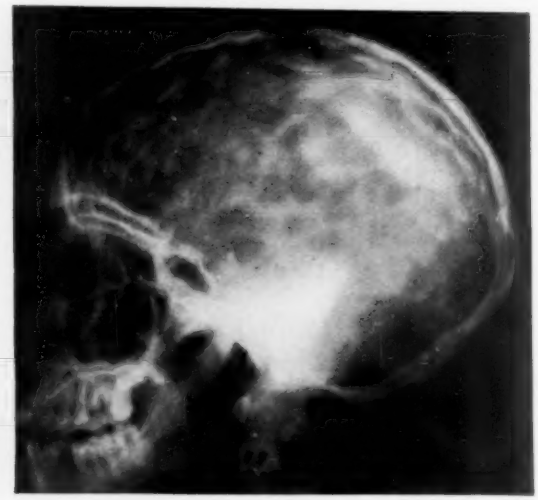

FIG. 12. Prominent convolutional markings in a girl aged sixteen, not associated with active intracranial disease.

other appearance than that due to prominent markings for the cerebral vessels. In some instances of this sort it is surprising to find on careful inquiry that no adequate trauma has ever been received to account for such a diagnosis, the roentgen misinterpretation having been made without any inquiry as to the history of the case. In connection with these medicolegal aspects of roentgen findings of the head it is not amiss to reiterate the author's view that the pineal gland can be demonstrated in a large percentage of normal individuals, despite the fact that undue stress is often laid upon finding of a shadow in this region, as in a very recent homicide case. It is true that calcified tumors do originate in this region; an excellent example of one has been observed by the writer (Fig. 13).

While dealing with this subject of anatomical variations it is not amiss to mention the extreme variations in the pituitary fossa in healthy individuals. Several roentgenologists have called attention to this condition.

In another group of cases unusually deep grooves for the meningeal arteries have led to error in roentgen interpretation, this having been put down as a sign of increased intracranial pressure due to a lesion such as brain tumor.

In another instance separation of the suture lines of the skull has resulted in a misinterpretation, and in one instance a case of chloroma was incorrectly diagnosed as fracture of the skull.

In other instances the petromastoid parietal suture, or the petromastoid occipital suture has been mistaken for fracture of the skull in cases in which an injury to the head has been received followed by hemorrhage from the external auditory meatus.

Calcification of the falx cerebri has been encountered several times. To the uninitiated the dense shadow cast by this lesion might be misinterpreted as a calcified brain tumor. In 2 cases observed by the writer no symptoms were associated with the lesion in question. One case was observed in a woman aged twenty-four, and the other in a man aged sixty-five.

Finally, Paget's disease of the skull has frequently been erroneously diagnosed as cranial syphilis. The correct diagnosis can be made by careful study of the skull and often by typical manifestations in other bones.

CONCLUSIONS

1. With improved technique, and particularly with the aid of the Potter-Bucky diaphragm so-called "dilated diploic veins," can be demonstrated in many apparently healthy individuals. These veins may be observed in only one portion of the skull, or on one side, or on both sides.

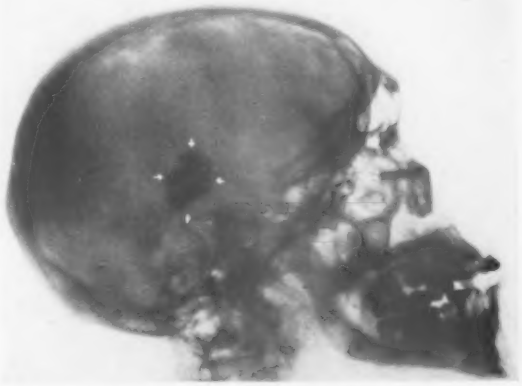

FIG. 13. Extreme deposit of calcium in a tumor in the region of pineal gland.

The pattern varies with the individual and may vary on the two sides of the same individual. The term "dilated diploic veins," should be abolished, substituting some anatomical term such as "prominent diploic venous channels." The appearance has been observed in healthy children at the age of ten years.

2. Prominent convolutional markings on the skull may be present in apparently healthy individuals.

3. Apparently healthy individuals may show: marked irregularities in the inner table of the skull; extensive depressions for the Pacchionian bodies; prominent suture lines and deep grooves for the meningeal arteries.

4. Calcium deposits in the pineal gland can be demonstrated in healthy individuals in early adult life.

DISCUSSION

Dr. Isaac Gerber, Providence, R. I. When Dr. Holmes asked me to open this discussion, I received a short abstract covering the contents of Dr. LeWald's paper, and I was instantly struck with the similarity of my experiences during the past 5 or 6 years with regard to appearances in the skull. Frankly speaking, I believe the entire thing is a matter of improvement of technique. Ten years ago skull examinations were made with plates and nothing else; pathological changes that we saw on plates were pretty gross; when we saw dilated vessels they were really dilated vessels, and when we saw signs of increased intracranial pressure, they certainly were those.

Gradually we have introduced the use of intensifying screens, the use of duplitized films, the use of superspeed films, and the use of Potter-Bucky grids, with all these other accessories. I remember when I first saw films that were made with duplitized films and double screens, I saw skulls of every person who had ever passed under my observation. It was only after sufficient experience that I realized that I was merely seeing things that I had not seen before, that were perfectly normal and that were merely being brought out by increased technical ability. The Potter-Bucky grid has added to that.

At least three-quarters of the slides of the various patterns of diploic markings that Dr. LeWald showed, I believe are things that we are all seeing now with the increased technical facilities at our command, and they don't mean anything. You merely have to learn to revise the standards of the pathological from the normal in the future, as our technical capacity is advancing.

We have gone through the same thing in the chest. Early chest films were pretty crude and almost everything we saw out of the way in the early days really meant pathology. As stereoscopic studies and the use of intensifying screens, duplitized films with stereoscopy, advanced, we saw certain fine structures that certainly could not be interpreted as pathological; we know they are perfectly normal. So in skull examination the capacity of seeing more will make us become more and more cautious as to where to place the limits of the pathological and the normal.

Another thing that was brought out by Dr. LeWald (and I believe it is of extreme importance) is the danger of relying on the data from an isolated roentgen examination for forming a definite diagnosis and advice as to treatment; I know it is pretty dangerous. It is dangerous in gastrointestinal work, it is dangerous in chest work, and it is triply dangerous in skull diagnosis. The roentgen-ray evidence is very valuable as a part of the study, but that without any other clinical evidence bearing it out will certainly not be of very much value.

Dr. Percival Bailey, Boston. I think perhaps the opinion of the neurosurgeons has not been correctly represented. As long ago as 1919 I learned to be very suspicious of increased vascularity of the skull. A young man twenty-five years old entered the clinic and I saw him. He had a typical Jacksonian attack in his right hand and face, and the roentgenogram showed very marked increased vascularity on the left side of the skull. I was so much impressed by it that I induced Dr. Cushing to let me operate on him, although he wasn't very enthusiastic about it. Needless to say, there was no tumor; and that impression has remained with me ever since. Since that time, increased vascularity of the skull means nothing to me unless there is considerable other evidence to go with it, and in our clinic we pay very little attention to increased vascularity of the skull, either diploic or arterial, unless there is considerable additional evidence.

Dr. LeWald, closing. I am very thankful to Dr. Bailey for his corroborative statements. I think that puts just the essential point of view of the neurosurgeon on what we as roentgenologists see.

MULTIPLE MYELOMATA

BY WILLARD J. STONE, M.D.

PASADENA, CALIFORNIA

THE specific malignant tumor formation known as myeloma is sufficiently rare to warrant the following report and to include the roentgen findings, upon which the early diagnosis may depend.

Myeloma was first described by Macintyre[1] in 1850 under the term mollities ossium. He reported the presence of albumose in the urine. Rusticky[2] in 1873 first used the term myeloma. Kahler[3] in 1883 completely described the condition and demonstrated the constant presence of albumosuria. The disease has been known by his name but priority should be given to Macintyre who first described the disease, or to Rusticky who first employed the term myeloma.

It will be recalled that myelomata are characterized by multiple, lymphocytic, myelocytic or plasma cell invasions of bone marrow throughout the body. These tumors lead to destruction of the bones involved. The cellular proliferation has many of the characteristics of sarcoma including the formation of new blood channels. The cause of these bone changes is unknown. Metastases do not as a rule occur, but if the growths break through the periosteum, metastases may occur in other parts of the body, i.e., the liver, spleen, lungs, brain, or kidneys.

The presence of albumose (Bence-Jones proteid) in the urine may lead to the diagnosis before any bone tumors can be felt. The albumose is believed to be derived from the elastin of bone tissue absorbed by the tumors. It persists during the entire course of the disease. The disease is more common in males above the age of forty years. I have been unable to find any record of benefit received from roentgen therapy. The disease invariably runs a fatal course.

CASE REPORT

G. McN. (199–847) white, male, aged fifty-six, was admitted to the Medical Service, Los Angeles General Hospital, December 4, 1923.

Main Complaint. Pain in the thighs when in sitting position and pain in the back upon movement.

Past History. Past illnesses unimportant. Family history negative as to any similar condition. In May, 1922, while lifting, the patient was seized with a sudden severe sharp pain in the mid-dorsal region of the back. This pain was transitory. About five months later, while riding in a street car, he was again seized with sharp pain below the right scapula. Osteopathic and chiropractic treatments increased the pains, which have been more or less constantly present since October, 1922. An orthopedic brace applied to the back in April, 1923, afforded no relief. About May 1, 1923, a portion of rib was resected at the Methodist Hospital by Dr. C. L. Lowman, after which he received roentgen treatment for two months. The pathologist's report, May 2, 1923, was as follows: *Gross findings:* "Small pieces of rib in which no definite tumor could be found but the density of the bone was increased." *Microscopic findings:* "A small nodule made up of large cells of

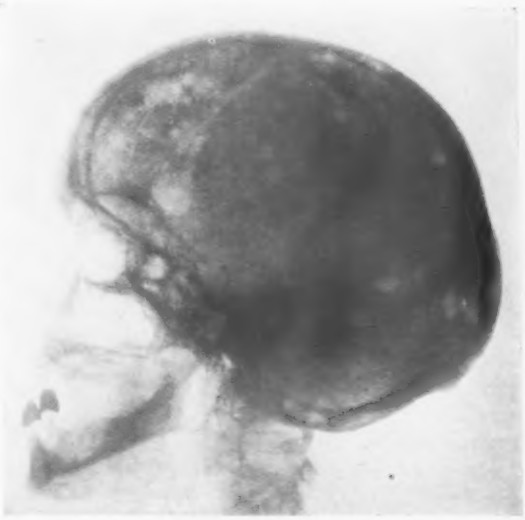

FIG. 1.

[1] MACINTYRE, WILLIAM. Case of mollities and fragilitas ossium, accompanied with urine strongly charged with animal matter. *Med.-Chir. Tr., Lond.*, 1849–50, xxxiii, 22 pp.

[2] RUSTICKY. *Deutsche Zischr. f. Chir.*, 1873.

[3] KAHLER, O. Zur Symptomatologie des multiplen Myeloms. *Wien. med. Presse*, 1889, xxx, 209; 253.

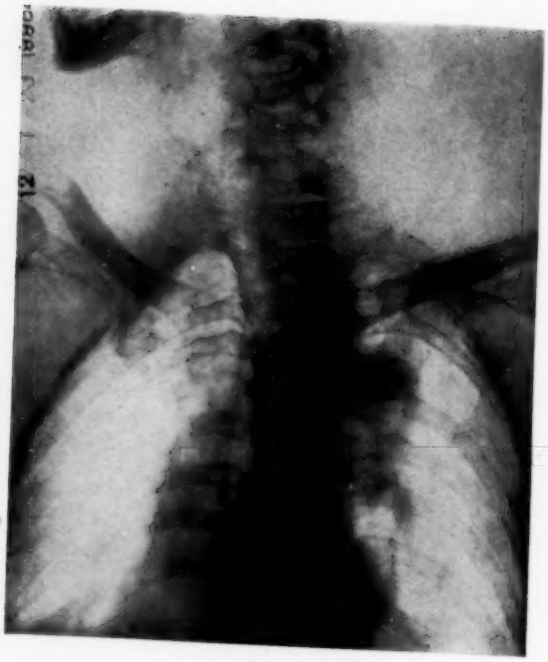

FIG. 2.

FIG. 3.

FIG. 4.

FIG. 5.

plasma type was found within the bone. In it were definite blood channels with endothelial walls. In the bone outside were small plasma cell foci."

Subsequent History. A tooth was extracted in July, 1923. The operation left a large ulcerated cavity, connected with a tumor focus in the mandible, which drained for about seven weeks. He was forced to bed about September 1, 1923, because of pain in the back. He has lost only 8 lb. weight in the past 18 months and now weighs 132. There had been no loss of appetite but marked loss of strength.

Examination. In appearance the patient was not anemic nor cachectic. The positive findings were as follows:

(1) Spasm of trapezius muscle in cervical region.

(2) Small protuberance of bone on the anterior third of the right mandible.

(3) Painful nodes about the size of walnuts, which were of bony consistency, attached to the cervical and dorsal vertebrae. The surfaces of the lumbar and sacral regions were roughened and irregular in contour. A spontaneous fracture of the right femur just below the greater trochanter had occurred.

(4) Rectal examination revealed an hypertrophied prostate, not suggestive of malignancy.

(5) The deep reflexes were hyperactive.

(6) The blood pressure was 115–80, the heart rate, rhythm, and valve tones were normal.

(7) R.B.C. 3,984,000; W.B.C. 3,400; differential: polynuclears 24 per cent, small lymphocytes 48 per cent, large lymphocytes 24 per cent, no myelocytes, normoblasts, nor eosinophiles seen. Hemoglobin 95; color index 1.2.

(8) Wassermann reaction negative.

(9) Roentgen-ray report: "The films show an advanced destructive process involving the entire spine, pelvis, trochanteric region of femurs, of the clavicles and many of the ribs, as well as the skull, of a type typical of metastatic malignancy. The shafts of the tibia and fibula on either side do not show the lesions."

(10) Urine: Albumin was present in considerable amount and granular casts were present. The xanthoproteic reaction was positive. Heating acidified urine to 60° C. brought down a dense cloudy precipitate, which increased in density to the boiling point when it suddenly cleared. On cooling reprecipitation occurred. Acidifying cold urine with HNO_3 brought down a dense precipitate which disappeared on boiling and reappeared on cooling. (Bence-Jones albumosuria.)

(11) Blood chemistry (fasting): Nonprotein nitrogen 37 mg. per cent; preformed creatinin 1.5 mg. per cent; uric acid 5.7 mg. per cent; sugar 111 mg. per cent.

Clinical Diagnosis. Multiple myeloma.

Death occurred from exhaustion on March 23, 1924. The autopsy findings were as follows: Multiple myelomata involving ribs, clavicle, spine and femur. Pathological fracture of right femur below greater trochanter, cortex very thin and narrow cavity replaced by a softened friable gray and pink semitranslucent appearing tissue; no normal appearing marrow remaining. Cortex of greater trochanter is greatly thinned and in areas only a suggestion of a shell remains. Over lower dorsal spine firm tumor apparently involving spinous processes could be palpated.

Pathological Diagnosis. Myeloma.

CLINICAL DIAGNOSIS OF COMMON SACROILIAC CONDITIONS*

BY M. N. SMITH-PETERSEN, M.D.

BOSTON, MASSACHUSETTS

THE sacroiliac joint is subject to the same conditions as any other joint,—trauma, inflammation, neoplasms. The first two mentioned, trauma and inflammation, are the conditions which will be dealt with in this paper.

In the great majority of cases it is a simple matter to differentiate between symptoms arising from a lesion affecting the lumbosacral region and one affecting the sacroiliac region. This differential diagnosis should be made by the orthopedic surgeon on the basis of a careful history and an equally careful examination. The roentgenologist should not be expected to make the diagnosis, but his interpretation of the roentgenogram should be considered as confirmatory evidence. The roentgenologist, however, is as a rule rather reluctant to give this confirmatory evidence, and often responds: "Without clinical findings we are not justified in interpreting this roentgenogram as showing pathology." The object of this paper is to overcome this seemingly insurmountable obstacle to cooperation between the roentgenologist and the orthopedic surgeon, by giving some of the signs and symptoms practically constant in sacroiliac conditions.

History. A careful history is a tremendous aid in making a diagnosis.

Trauma. If trauma is present it should be described in detail. Leverage transmitted through the ham strings unilaterally to the pelvis is very effective in bringing about a sacroiliac strain.

The Effect of Positions on Pain. Standing: The patient is apt to stand on the unaffected leg with the knee on the affected side in the position of slight flexion. This position diminishes weight transmission through the affected side and also relaxes the ham strings.

Sitting. Usually the patient sits on the opposite buttock. Again, he is avoiding transmission of weight to the affected side of the pelvis, and also protecting the sensitive sciatic nerve from pressure.

Lying. The patient, as a rule, is comfortable on his back or on the opposite side; he is unable to lie on the side affected.

Walking. Walking aggravates the pain. Going up stairs is likewise apt to aggravate the pain; as a rule, the patient goes up stairs child-fashion, dragging the affected leg after him.

Straining at Stool. This is equivalent to raising the intrapelvic pressure and aggravates the pain in acute sacroiliac cases, whether traumatic or inflammatory.

Distribution of Pain. In regard to the patient's description of the distribution of pain; this of course is subjective and cannot be anatomically accurate. It is distinctly helpful, however, when we consider the innervation of the sacroiliac joints. This is derived from the following sources: (1) Anteriorly, from the lumbosacral cord; (2) posteriorly, from the first and second sacral nerves; (3) inferiorly, from the superior gluteal nerve; (4) from the obturator nerve.

There is some question as to the innervation derived from the obturator. The opinions of various anatomists differ on this point. Bardeleben and Morris, however, agree on the first three sources of innervation.

On the basis of the innervation just described we may have pain referred along the fourth and fifth lumbar and first and second sacral nerves. In other words, we may have pain referred to the posterior aspect of the thigh as well as to any part of the lower leg. The type of pain almost constantly present, however, is the pain referred along the first and second sacral nerves, namely, posterior aspect of the thigh, anterolateral and posterior aspect of the lower leg and lateral aspect of the ankle (Figs. 1 and 2). Because of the innervation from the superior gluteal nerve we are also apt to have pain referred to the sacrosciatic notch, extending in the anterolateral direction along the distribution of the superior gluteal nerve to its

* Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

termination in the tensor fascia femoris muscle.

Finally, pain over the distribution of the internal obturator nerve, namely, the inferior, mesial aspect of the thigh. I have found pain referred to this area in 2 cases only; both cases were proven by operation to have a chronic inflammatory process in the sacroiliac joint.

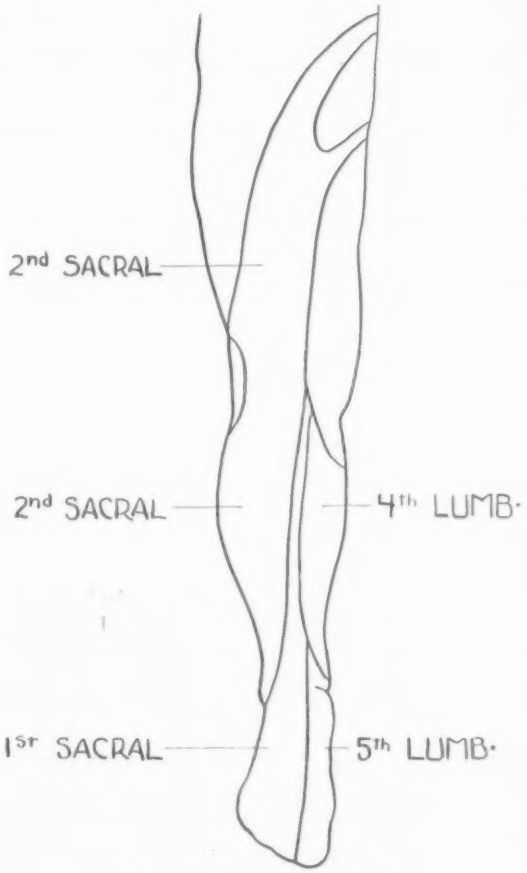

FIG. 1. From Tilney and Riley.

The above description of peripheral sensory distribution and the diagrams are taken from Tilney and Riley, "Anatomy of the Central Nervous System." These charts agree with the distribution of pain which I have found in a great many of my sacroiliac cases; they do not agree, however, with the peripheral sensory distribution as described by Head and Seiffer.

These are all practical points and practical questions which a roentgenologist can easily ask a patient while he is taking his roentgenograms. It is hardly possible for the roentgenologist to carry out a detailed examination such as the orthopedic surgeon should perform. If the roentgenologist, however, will observe his patient as he moves about he can gather valuable information. He can also easily palpate certain points without taking additional time or annoying the patient.

The points which are particularly apt to be sensitive in sacroiliac conditions are:

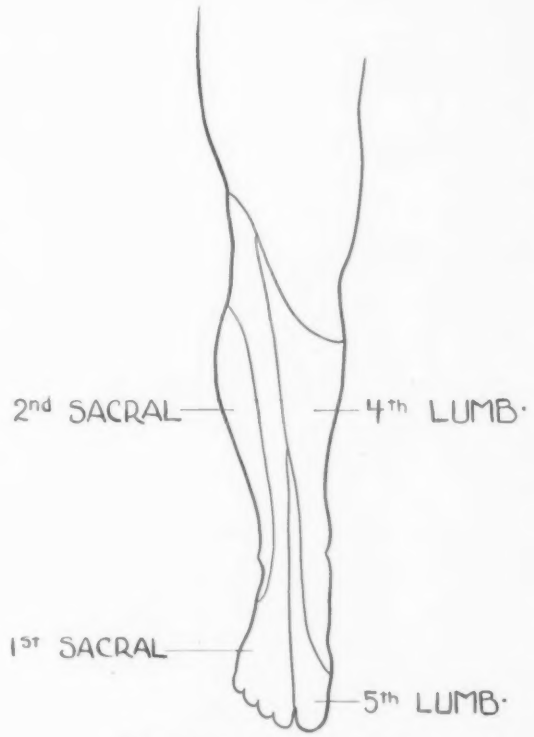

FIG. 2. From Tilney and Riley.

1. The inferior sacroiliac ligament between the posterior superior and posterior inferior iliac spines.

2. Sacrosciatic notch. At this point the superior gluteal nerve curves around as it passes forward and since it sends a branch to the sacroiliac joint we are very apt to have sensitiveness along the main nerve trunk.

3. Sciatic nerve trunk; half way between the ischial tuberosity and greater trochanter, at the level of the gluteal fold.

MOTIONS

In order to demonstrate the limitation of motions in a sacroiliac joint condition we have to compare them with limitation of motions due to a lumbosacral condition. For the purposes of this paper and for the sake of clearness I am going to analyse one motion only, that of flexion of the spine. We will analyse this motion in the three positions—standing, sitting and lying.

Standing. In lumbosacral conditions the muscle spasm is apt to keep the lumbosacral region rigid, and forward bending takes place at the hips and in the upper lumbar and dorsal regions. In sacroiliac conditions the patient is apt to bend forward first by flexing the lumber spine, then by tilting the pelvis until the ham strings become taut. At this point he either stops because of pain or flexes his knee on the affected side so as to relax the ham strings and then is able to bend over farther (Fig. 3).

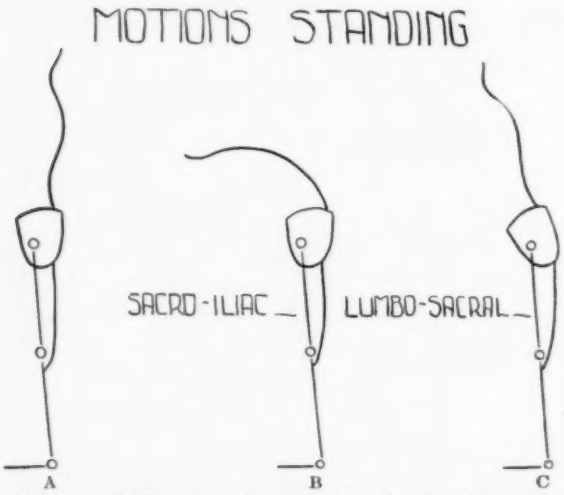

FIG. 3. Flexion of spine. A. Standing position. B. Flexion of spine in sacroiliac cases—good motion in lumbar spine, pelvis does not move. C. Flexion of spine in lumbosacral cases—no motion in lumbar spine, pelvis tilts forward at the hips.

Sitting. The only difference between flexion standing and flexion sitting is that in the latter the ham strings are relaxed and consequently no leverage is transmitted to the pelvis. In sacroiliac cases it is quite remarkable to note how freely the patient bends forward from the sitting position, even though flexion standing was markedly limited. In lumbosacral cases attempt at flexion of the spine in the sitting position is just as limited as in the standing position (Fig. 4).

Lying. Passive lumbar flexion by the examiner flexing the hips on the pelvis is of particular value in differentiating between lumbosacral and sacroiliac joint conditions. Passive flexion of this sort eliminates to a great extent muscle leverage and I have come to feel that we get more of a pure joint motion than when we attempt the same test in the standing and lying positions actively. In lumbosacral conditions, of course, this test is productive of pain and it is impossible to flex the lumbar spine. In sacroiliac conditions, however, there is no leverage transmitted to the pelvis but the pelvis moves as a whole and consequently the motion is apt to be free and unaccompanied by pain. There are cases of acute sacroiliac conditions where this motion would be productive of pain but much less so than active flexion in the standing position (Fig. 5).

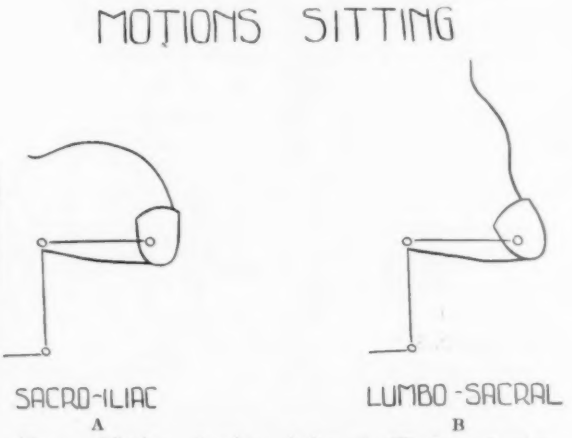

FIG. 4. Flexion of spine, sitting. A. Flexion of spine in sacroiliac cases—good motion in lumbar spine, pelvis remains fixed. B. Flexion of spine in lumbosacral cases—no motion in lumbar spine, pelvis tilts forwards.

Just a word about the special test usually referred to as "straight leg raising." This test consists in raising the leg from the table with the knee extended. By keeping the knee extended the ham strings gradually become taut and leverage is transmitted unilaterally to the pelvis. If the sacroiliac joint on that side is sensi-

tive this test is productive of pain. The same test carried out on the opposite side from the side affected is, as a rule, not productive of pain unless the sacroiliac joint condition is extremely acute.

In regard to the interpretation of roentgenograms of sacroiliac joint conditions, these are best considered under the following headings.

1. Sacroiliac strain or relaxation.
2. Inflammatory conditions.

SACROILIAC STRAIN OR RELAXATION

In the majority of acute cases the roentgenograms are negative. They may show disalinement, which is best demonstrated at the pubis. In chronic cases proliferative changes are frequently seen along the inferior joint line, at the pubis, and at the attachment of the iliolumbar ligaments. Proliferative changes in the last named region are also present in cases of lumbosacral strain. In chronic cases there may be increased density along the joint line but this is not so common a finding as the proliferative changes. Disalinement also may be present the same as in acute cases.

INFLAMMATORY CONDITIONS

Tuberculosis. In the early stages there is increased density along the joint line and in the soft tissues at the inferior margin of the joint. In the later stages there is in addition erosion of the joint line and bone atrophy in the ilium and in the sacrum.

Gonorrheal Arthritis. Gonorrheal arthritis is more apt to involve the entire joint than is tuberculosis; it is frequently bilateral. In the early stages there is markedly increased density along the entire joint line and this increased density is more intense than in tuberculosis. In the later stages there is in addition erosion of the joint line and areas of bony fusion.

Infectious Arthritis. In the early stages the appearance is very similar to early tuberculosis and it is impossible to differentiate between the two. In chronic infectious arthritis, however, the bone atrophy is very much less marked than in tuberculosis.

I have now operated on over 30 cases for sacroiliac relaxation and the results have been uniformly successful. I have also had about 20 cases with inflammatory conditions. The majority of these have been successful but some cases of tuberculosis still have draining sinuses although relieved from all pain. This is fairly good proof that the diagnosis in these cases was correct, and the diagnosis was made on the basis of an examination the practical points of which I have just given you.

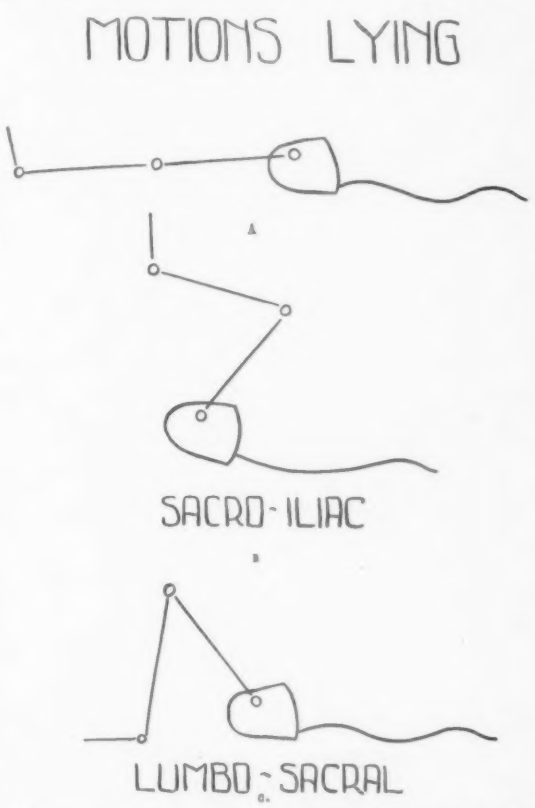

FIG. 5. A. Lying at rest. B. Passive flexion of lumbar spine in sacroiliac cases—good flexibility of the lumbar spine. C. Passive flexion of lumbar spine in lumbosacral cases—lumbar spine remains fixed and hips cannot be flexed except through a very limited arc.

DISCUSSION

DR. ROLAND HAMMOND, Providence, R. I. There is very little that any one can add to such a complete paper as Dr. Smith-Petersen has presented. I know such a statement as that is usually made at the opening of any discussion, but Dr. Smith-Petersen is recognized by the orthopedic men as being particularly clearcut in his statements in any paper that he writes. That is the reason I have been willing to make such a hackneyed introduction.

From the conversation I heard in the rear of the room before this paper was presented, I judge that there is considerable interest in this subject and also some confusion in the minds of a great many medical men. I am free to admit that the confusion exists to a large extent among the orthopedic men themselves, but it has been possible in the last few years to get together some rather conclusive facts in examination, and Dr. Smith-Petersen has very well put those down briefly.

Roentgen-ray examination in a large number of these cases has never been of very much help to me. The proliferation that he speaks of, in the lower part of the sacroiliac joints, is conclusive when present, but it is so often lacking. Of course, the proportion of tuberculous or gonorrheal arthritis is very unusual, as compared with the numerous conditions of sacroiliac strain and lumbosacral strain.

Perhaps I can serve no better purpose than to emphasize the point that Dr. Smith-Petersen made regarding cooperation between the orthopedic surgeon or the practitioner and the roentgenologist. It has been my experience so many times to have a report sent back with either negative or inconclusive findings, and something definite would be of much more value to the orthopedic surgeon.

Dr. W. E. Chamberlain, San Francisco, Cal. The subject of sacroiliacs is a very controversial one. Dr. Goldthwaite began to talk about it in 1905 and soon the roentgenologists thought they could demonstrate these sacroiliac slips or displacements if they existed, and then they failed to demonstrate them and became very much discouraged. I think that the attitude of Drs. Baetjer and Waters was rather characteristic of the general attitude of roentgenologists when they said that these sacroiliac strains or displacements did not exist. As a matter of fact, in 1919 I went back to Dr. Goldthwaite's paper and studied it over again and found that he never expected to see up and down displacements; that is, displacements in the sacroiliac joint which could be demonstrated by the usual roentgenogram. He distinctly said that the displacement would be rotatory and obviously the pictures we took in those days were not calculated to show rotatory displacements.

Since 1919 we have been studying the sacroiliac by roentgenograms, always including the symphysis pubis. In our first series of 30 cases we were especially struck by the tremendous number of cases in which we corroborated the clinical diagnosis made by such methods as Dr. Smith-Petersen has so wonderfully shown us on the charts; we corroborated those diagnoses in a very high percentage of cases.

I read a paper before this Society in 1922 on this subject and it has continued to interest me tremendously. I find that we are not hitting the mark, we are not helping the clinician in quite the large percentage of cases that I thought at first we were going to, and I think Dr. Smith-Petersen said the whole thing in a nutshell when he said that when the roentgen ray demonstrates these conditions, it is demonstrated by something that you see at the symphysis pubis; that is, an up and down displacement at the symphysis, the result of atrophy displacement in the sacroiliac joint. As a matter of fact, we have had cases in which the roentgen examination has been of service in arriving at a diagnosis; especially in cases of relaxation. In our technique we have the patient stand up in front of a vertical Bucky diaphragm, slip a block of wood under one foot and take an anterior roentgenogram and then the same thing with the other foot. We find we can demonstrate and to some extent measure the degree of displacement, and the Smith-Petersen operation on the sacroiliac joint has produced a nice series of cases and some complete clinical curves in some rather extreme cases of sacroiliac relaxations with marked symptoms.

Dr. Smith-Petersen, closing. I have very little to add; I agree absolutely with what Dr. Chamberlain has said. The only reason I do not approve of taking roentgenograms with the patient standing on one foot and then on the other is that roentgenograms taken in this fashion are very difficult of interpretation; the relation of the pelvis to the lower spine becomes rather complex and I do not believe that disalinement of the sacroiliac joint can be demonstrated in this fashion. I believe you get more consistent findings if you take stereoscopic roentgenograms including the pubes.

URETERO-PYELOGRAPHY IN THE DIFFERENTIAL DIAGNOSIS OF THE UPPER URINARY TRACT*

BY JOHN D. LAWSON, M.D.

Department of Radiology, Woodland Clinic

WOODLAND, CALIFORNIA

DEMONSTRATION of the contour and outline of the storage and transmitting portions of the upper urinary tract was first made in 1904 when Klose injected a bismuth suspension into the kidney pelvis in a case of double ureter and produced roentgenograms of the injected pelvis.

This attempt, rather crude in the light of present knowledge, was the precursor of one of the most important phases of urinary diagnosis. The utility of this procedure is not limited to the above mentioned field, for there are other abdominal conditions in which the pyelogram may absolutely make the differential diagnosis.

FIG. 1. Hydroureter with hydronephrosis resultant upon obstruction at the brim of the pelvis due to twisted pedicle of ovarian cyst.

It is not my purpose to enter into the historic features of pyelography, but due mention must be given to the two outstanding features which have made this method of investigation safe and satisfactory, namely, the Potter-Bucky diaphragm and the use of sodium bromide as the opaque medium.

The technique used in our Clinic is as follows: The radiopaque medium of 15 per cent sodium bromide solution is injected through an opaque catheter from a burette. The flow is allowed to proceed slowly until the patient complains of pain in the loin, at which point the injection is stopped. Too rapid injection causes spasm and gives the patient great pain without filling the pelvis properly. The use of a syringe, I believe, is not good since rupture of the pelvis may occur as is demonstrated by the accompanying roentgenogram (Fig. 4). The use of double injections, i.e., both pelves simultaneously, is not a routine procedure, but we make no objection to it. The exposure is then made, using the Potter-Bucky diaphragm with varying exposures, depending, of course, on the dimensions of the subject. We should not overlook the importance of taking stereoscopic views as a routine. It is true that usually we will not need the added plate, but there is the occasional case where a stereoscopic set is of undoubted value.

FIG. 2. Terminal stage of hydronephrosis.

* Read before joint meeting of Western Section, AMERICAN ROENTGEN RAY SOCIETY and the PACIFIC COAST ROENTGEN RAY SOCIETY, Mount Rainier, July, 1924.

In pyelography, as in other phases of roentgenology, we must consider the normal. The estimation of normal pelvic capacity varies with the individual roentgenologist and urologist, some claiming that 5 c.c. is the normal limit, while others believe that a pelvis may accept 14 c.c. without being considered pathological. However, in general, I believe that any pelvis which does not accept more than 8 or 9 c.c. is to be regarded as normal. There is opportunity for error in estimation if one relies entirely upon the capacity as measured by the burette or syringe, because a certain amount of the medium may return past the catheter into the bladder, especially if there is some delay in injection, if the injection is allowed to flow too slowly, or if a small catheter is used. We may check this by including the bladder in the film, and, if the density of the bladder area is increased over the normal, we must discount any measurements.

FIG. 3. Hydronephrosis due to ureteral pressure exerted by teratoma of the ovary. This case had a horseshoe kidney not diagnosed roentgenographically.

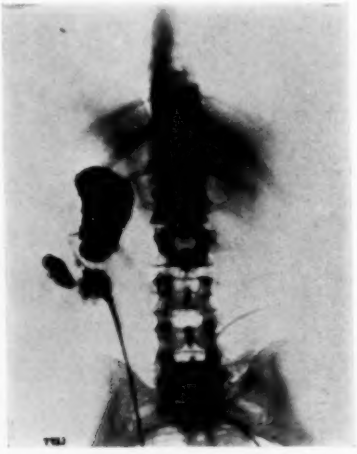

FIG. 4. Rupture of the pelvis with extravasation of sodium bromide due to too much pressure exerted on a syringe.

HYDRONEPHROSIS

Hydronephrosis is probably the most common abnormality met with in pyelography. However, when we make a diagnosis of hydronephrosis, in the large majority of cases we have only given the physician information of which he is already possessed as a result of his cystoscopic and clinical observation. The reason the patient is referred to us is to find the cause for the hydronephrosis. In other words, the physician wants a differential diagnosis and the mere statement of hydronephrosis is of no value.

Hydronephrosis is essentially due to an obstruction to the outflow of the urine. It may be produced in many different ways and it is not always possible—probably in half of the cases it is not possible—to give an absolute diagnosis as to the direct etiology. Sometimes, however, we may be able to state that the obstruction is at a certain level. Correlation of this information with a knowledge of other pathology present may be of material aid to the physician.

Two interesting cases which I observed recently illustrate this point well. A female, aged twenty-nine, entered the Clinic complaining of symptoms typical of renal colic, and a tentative diagnosis of ureteral calculus and ovarian cyst was made. Cystoscopic examination revealed an obstruction of the ureter about 5 cm. from the vesical orifice. After much manipulation a dilator was passed and a large amount of purulent urine was discharged. A pyelogram showed a definite hydronephrosis and hydroureter beginning at about the location noted in the cysto-

scopic examination. After repeated irrigations of the pelvis and continued recurrence of the trouble, laparotomy was performed for the removal of an ovarian cyst, as it was thought possible that the obstruction was due in a measure to this latter condition. Bilateral teratoma of the ovaries was found at operation. One of the cysts was twisted and had involved the ureter in the twist. It was evident that this was the cause of the obstruction. Operation also revealed a horseshoe kidney not diagnosed roentgenographically.

In the other case, also a woman, which was seen by us some two years ago, there

FIG. 5. Calcified kidney in the major pelvis. No opaque solution has been injected on this side.

was definite abdominal tumor associated with symptoms of renal colic. An absolute obstruction was noted just below the brim of the pelvis, the radiopaque catheter being stopped at this point and an injection of radiopaque medium being impossible. Diagnosis of ovarian cyst with twisted pedicle was made, and operation demonstrated the ureter caught in the pedicle and twisted to such an extent that there was a total obstruction. In both cases localization of the obstruction roentgenographically assisted in making the diagnosis.

Ureteral obstruction by tuberculous adnexa and pelvic malignancy with the production of hydronephrosis is not at all uncommon.

Pyelitis, with its recurring obstruction, and renal calculus are probably the most common etiologic factors. In a fairly high percentage of cases ureteral calculus may be demonstrated and the diagnosis assured. In the pyelitis cases, however, we are not able to be of any assistance other than to give an estimate of the amount of distention of the kidney pelvis. Anomalous renal vessels may also exert sufficient pressure on the ureter to produce hydronephrosis as was noted recently by Jameson.

CALCULUS

Renal and ureteral calculi cause nearly as much anxiety to the roentgenologist as biliary calculus. Either may or may not

FIG. 6. A common deformity observed in hypernephroma.

be shown, depending on their chemical composition. Generally speaking if we have a renal calculus which does not show in the ordinary examination of the urinary tract we must assume that its density is the same as that of the surrounding tissues. The injection of a radiopaque medium of heavy density will then be of assistance as the stone will occupy some of the space ordinarily taken up by the medium, and being of less density, will cast a negative shadow.

In the diagnosis of renal calculus we also have the various extra-renal shadows causing confusion, gall stones, fecaliths and phleboliths being the chief of these. We also have to consider moles on the back and other skin lesions which may cast a shadow. It is in this particular connection that I believe we will derive most benefit from

the stereoscopic films, as there is no doubt that gall stones and other opacities generally can be focused by this means at a level other than the kidney level.

TUMORS

Certain renal tumors produce characteristic deformities by which we may denote the exact type of tumor, thereby materially assisting in the clinical diagnosis. Hypernephroma, sarcoma and carcinoma are the chief kidney tumors with which we have to deal, the latter being a relatively rare condition. The spider pelvis of hypernephroma is quite characteristic. However, we do not always obtain a demonstration in this form. The location of the lesion will naturally determine the type of deformity noted. Very often in carcinoma we find projections into the calyces and pelvis, giving them an irregular outline, ragged in appearance. This is probably the most common differential point between hypernephroma and carcinoma, as the pelvis and calyces in the former are practically always smooth in outline.

The various benign tumors and cysts are of such rare occurrence that they are probably not recognized as such from the roentgen examination and will generally be confused with hypernephroma unless there is some demonstration outside of the genito-urinary tract which will give added information.

CONGENITAL DISEASES AND ANOMALIES

There have been numerous congenital anomalies diagnosed by pyelography which, previous to its advent, were discovered only by surgery or at autopsy. The horseshoe kidney is probably the most common of these conditions and even in pyelography we may not suspect it where there is no fusion of the calyces, or where the isthmus is quite narrow. Cases of double pelvis are not infrequent, while unilateral double kidney is relatively rare. Probably the most uncommon of these anomalies is that of a double ureter. In this condition both ureters occupy their normal positions in the bladder, but lead to the same pelvis, the kidney being definitely on one side.

Polycystic disease is one of the conditions in which we may be able to give a definite diagnosis; this is generally arrived at by the presence of marked enlargement of both kidneys with stretching out of both major and minor calyces and pelves. However, we occasionally find large bilateral kidney shadows due to an extensive hydronephrosis and the contour of the kidney shadow does not prove that the case is one of polycystic disease. Hence, from the roentgenologist's viewpoint, the pyelogram is often quite necessary to differentiate between the two conditions, as the pelvic outline is absolutely different in the two.

CONCLUSIONS

It is my belief that the time will soon come when no diagnosis involving the upper urinary tract, other than one of an acute infectious process, will be made without the help of the roentgenologist, especially by means of pyelography. We can bring about this recognition by bearing in mind just what help the physician expects, especially along the line of differential diagnosis, and by taking care that our reports cover the points in which he is interested.

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Information of interest to all readers will be found on page vii. Lists of officers of The American Roentgen Ray Society and The American Radium Society will be found on page preceding Editorial Section.

THE VERSATILITY OF ROENTGEN RAYS*

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IN all the history of science there is no more brilliant page covering a period of less than thirty years than that which is concerned with roentgen rays. From the status of a misunderstood and somewhat dangerous plaything, they are only now becoming a useful tool of astonishing versatility and of untold possibilities in the fields of biology, pathology, medical diagnosis, physics, chemistry and numerous phases of business and industry. Even yet the roentgenologist may little realize, in the process of application of roentgen rays to diagnosis of human ills and to the obliteration or alleviation of suffering, that this same agency is being applied by the botanist, the physicist in his searchings of atomic anatomies, the chemist, the metallurgist, the great industrial corporation, or even the ordinary mechanic, to the solution of almost innumerable problems. Those transverse electromagnetic vibrations, or bullet-like quanta of energy, which we call *x* or roentgen rays and which we know to be in every way similar to ordinary light except that the frequencies are on the average about 6000 times as great as yellow light, are meeting manifold demands; in fact, they are so helpful in many instances that there is an increasing tendency to expect them to solve any experimental or theoretical impasse after all other tools of science have failed. Hence a brief survey of the matchless versatility of roentgen rays must also serve as a delimiting process.

The applications of roentgen rays may be roughly divided into, first, those depending upon direct utilization of the radiation; second, the determination of crystal structures; and, third, the founding or testing of theories of the structure of the atom. This seems to be a better system of classification than any attempt to apportion the applications among the various sciences, simply because it is impossible in these days to define the boundary lines between sciences. These three classes will be considered systematically and briefly. It is obvious that a monograph instead of a paragraph might easily be written on each one of the thirty-seven general fields of application.

I. DIRECT APPLICATIONS

1. *Roentgen Therapy.* The well-known treatment of tumors by roentgen rays of course depends upon the preferential

*EDITOR'S NOTE: The following article is published in our editorial department because of its unusual nature and wide scope. So far as we know, no such general resumé of the application of roentgen rays to many branches of science and industry has ever before been published.

destructive action of the radiation upon cells with abnormal growth function. It is an occasion for great rejoicing that roentgenologists after years of empirical measurements and estimations of dosage and protection are applying the experimental results of physicists upon the fundamental laws of roentgen-ray production to quantitative treatment in terms of wave lengths and intensities measured by accurately calibrated ionization chambers. Here is a pertinent example of the age-old truth that any good thing may be very harmful if ignorantly used. The newer results in the actual curing of cancerous conditions when not hopelessly acute, and even in the temporary relieving of suffering in far progressed cases stamp these rays, intelligently used, as literally a great beam of light searching the dark places in medical science. The qualifying phrase, intelligently used, should effectually answer attacks upon the use of roentgen rays as being deadly dangerous to man because experiments with mice result in death, sterility or abnormal young. That phrase indicates scientific dosage and scientific protection based upon the quantitative laws of the absorption of roentgen rays by matter. It signifies and calls for many careful experiments upon the effects of roentgen rays upon all kinds of tissue, upon gland secretions and upon all physiological functions.

2. *Roentgenography—Medical Diagnosis.* This application is so well known as to require little comment. Many people have wondered how the medical and dental professions ever managed to get along without the roentgenogram or the shadow on the roentgenoscopic screen. The fact that roentgen rays penetrate matter and are differentially absorbed by regions differing in density enables the exact location of the tumor which is to be rayed, the diseased tissue, the incipiently tuberculous lung, the broken bone and its proper setting, the pin caught in the child's throat, the decayed tooth and its proper filling. Thus do our amazed eyes see where before 1895 they could not. The use of auxiliary agents better to define the tissue or organ under observation, such as bismuth salts and gases, has developed into a science in itself.

3. *Roentgenography—Industrial Diagnosis.* Only within the past four or five years has it come to be realized that industrial products may be examined for internal defects by means of roentgen rays just as successfully as the human body. Consider how the safety of living in this age depends upon the strength and reliability of bridge and sky-scraper steel girders, steel rails, industrial plant equipment, especially for high temperature and pressure processes where faulty construction would result in conflagration, or all types of ordnance. Outwardly these may appear perfect whereas inwardly there may be, as recently shown in tests at the Watertown Arsenal, offset cores, gas pockets, sand and slag inclusion, "pipes" (or cavities left when liquid metal shrinks in solidifying), spongy metal, cracks, etc. These imperfections may be readily detected roentgenographically through more than three inches. By means of roentgen rays not only may faulty castings be rejected, but an entirely new technique of controlled casting and successful substitution of castings for forgings gained. Roentgen rays are now being used also to detect flaws in arc electrodes and similar products. Roentgenographic examination of coal for classification as to inclusions, slate, etc., is a promising possibility of the near future.

4. *Roentgenography—A New Tool for Mechanics, Detectives and Customs Officials.* The General Electric Company has just perfected a small portable roentgen-ray apparatus with which plumbers may locate pipes hidden in walls or under floors, electricians may find wires exactly and almost instantaneously, and carpenters may know just where beams and nails are before proceeding to new constructional work. We are not surprised, then, that roentgen rays are becoming a valuable ally of the detective and the customs official in discovering concealed articles of value.

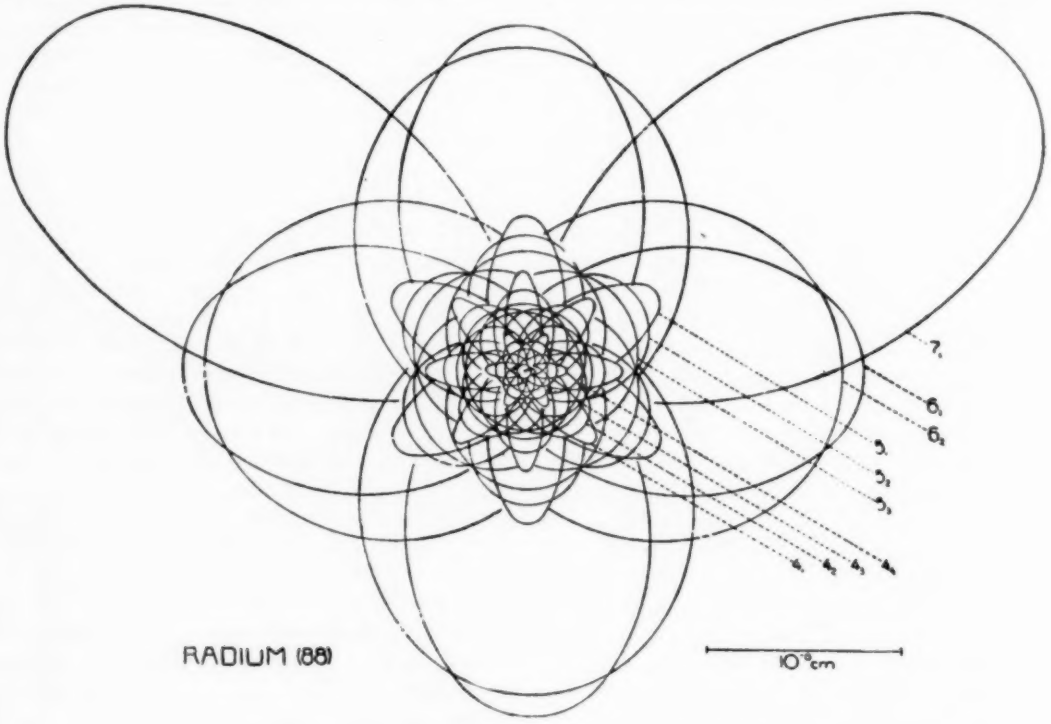
5. *Seed Germination.* Very little has been done so far in testing whether roentgen rays may have the same beneficial results as ultraviolet light upon the growth of organisms, seed germination, prevention of rickets, etc. Some experiments on hastening seed germination have given positive results.

6. *Stone Coloration.* Roentgen rays produce coloration in glass, white topaz, amethyst, and other minerals which find application in jewelry. Temporary colors are produced also in crystals of rock salt, sylvite and other transparent substances.

7. *Fluorescence.* Many substances become luminescent or fluorescent in a beam of roentgen rays; in other words, these substances have the power of absorbing roentgen-ray energy and re-emitting as visible light. Roentgen discovered *x*-radiation when his keenly watchful eyes beheld a barium platinocyanide screen brilliantly luminescent near a tube with which he was conducting cathode-ray experiments.

There are many useful practical applications of this interesting property: for example, the immediate detection of the difference between a diamond and a glass substitute. Some substances, particularly sulfides and silicates, do not fluoresce unless a minute quantity of impurity is present; hence, here is a method for the indication of chemical purity. The alkali halides and other salts under roentgen rays produce fluorescent bands in the ultraviolet whose positions are sharply characteristic for each.

8. *The Activation of Catalysts.* One of the most promising fields for investigation is in the field of oxidation catalysis. A preliminary study in Germany within the past year has shown that a platinum catalyst is activated by roentgen rays so that the yields of sulfur trioxide from the oxidation of sulfur dioxide are increased by as much as 35 per cent at temperatures considerably below the optimum range. The activation was produced only in the presence of slight traces of moisture so that evidently the roentgen rays caused an active layer of a peroxide on the catalyst. The whole question is being investigated for this process, as well as the oxidation of ammonia, in the new laboratory in the Department of Chemical Engineering at the Massachusetts Institute of Technology, looking to increased yields, lower required temperatures and pressures, and less expensive catalysts.



STRUCTURE OF THE RADIUM ATOM

FIG. 1.

9. *Chemical Reduction.* A few cases are known in which roentgen rays affect or cause chemical reactions. Iodic acid and potassium permanganate are both reduced by roentgen rays. This may be the explanation of the fact that absorption edges of some materials seem to have a fine structure, due to an element in more than one condition of valence. Organic compounds such as ortho-nitro-benzyl alcohol are completely decomposed by roentgen rays. This field offers great possibilities, particularly inasmuch as there are involved simple reactions, reactions in the presence of inactive metal colloids which, however, produce secondary rays, and reactions in the presence of colloids which are catalytically active and also produce secondary roentgen rays.

10. *The photoelectric conductivity* of solid dielectrics changes markedly under roentgen rays and there is a considerable variation depending upon the allotropic form. Sulfur has been recently studied in this connection. Like ordinary light, roentgen rays greatly reduce the electrical resistance of selenium.

11. *The disruptive potential* of an explosive reaction is lowered by roentgen rays. The relationships are so definite that the phenomenon could be made a measure of the intensity and hardness of roentgen rays. Therefore, they should be a valuable agency in the whole study of the fundamental mechanism of explosions.

12. *Gaseous Ionization.* Inasmuch as monochromatic roentgen rays may be easily obtained and the intensity controlled, they are far superior to arcs or radium for ionizing gases. The photographed tracks of β-particles or electrons photoelectrically ejected by primary roentgen rays are of great theoretical significance. Furthermore, the effect of ionization in explosions and detonations may be easily and quantitatively studied. Wendt and Grimm recently found that so-called "antiknocks," such as tetraethyl lead, act by absorbing electrons on the explosion front. Ionization was produced in their experiments by an arc whose constancy of action is open to serious doubt. This mechanism may be studied with certainty by means of roentgen rays.

13. *Anodic polarization* is materially increased by roentgen rays with consequent possible applications in electrochemical processes, particularly the oxidation of organic compounds.

14. *Photochemical reactions* provide an excellent field for roentgen rays, again because wave lengths and intensities may be so readily controlled. The oxidations of benzaldehyde, rubber and oil are accelerated to an enormous extent if roentgen rays are permitted to enter the reaction vessel. The radiation hypothesis may be subjected to searching test in such experiments which may be followed quantitatively.

15. *Corrosion of metals* seems to be profoundly affected by roentgen rays as also by ultraviolet light. It may prove possible to passivify surfaces and to study the mechanism of corrosive action by this new method.

II. ROENTGEN RAYS AND CRYSTAL STRUCTURES

16. *Elements.* Only about ten years ago Laue predicted that crystals, because of the regular marshalling of atoms in parallel planes within them, should act as a diffraction grating for roentgen rays in the same way as finely ruled lines on glass diffract light. Today the actual crystalline structures of forty-three of the chemical elements, practically half of those which have been discovered, are known with a considerable degree of exactness. We are coming to know more about the solid state of matter than any other; we have more information bearing upon the actual existence of atoms and of the forces between them than was ever vouchsafed through the intermediation of any other experimental tool. It is now possible to properly correlate and explain the physical and chemical properties of these fundamental building blocks of matter from a knowledge of atomic arrangement and dimensions. The several ingenious experimental methods by which roentgen-rays are used to discover inner architecture have caused to be written in large letters upon History's page the names of Laue, the Braggs, Hull, Debye, Duane, Siegbahn, Seeman and others. Difficulties of experiment and interpretation

are enormous, but with the aid of the mathematical theory of space groups and improved technique the puzzle of the remaining elements will be solved. Just now the structure of *solid argon*, one of the rare inert gases of the atmosphere, has been announced as composed of face-centered cubes with an edge length of 5.43×10^{-8} cm. An idea of the magnitude of this experimental achievement is given by the fact that these crystals were formed at about $-200°$ Centigrade.

17. *Allotropy and Polymerization.* The roentgen-ray crystal method explains and detects the different forms in which the same element can exist; carbon, cobalt, sulfur, tin and iron atoms, for example, may arrange themselves in more than a single kind of space lattice. Anomalous behavior of metals appearing as sudden discontinuities in the variation of physical properties with temperature and pressures is usually due to polymorphic transitions immediately detected by roentgen rays. On the other hand, recent work with tungsten single crystals showed sharp discontinuities in tensile strength as temperature was raised, but absolutely no change in crystalline structure. Again the results of roentgen-ray analysis tell us at once why graphite with perfect slip-planes, weak crystalline forces and large distances between planes, is so good a lubricant while a diamond, also carbon, is so hard and actually an abrasive. De Smedt in new and beautiful researches finds that the degree of polymerization of liquids may be exactly ascertained from roentgen-ray diffraction rings; thus for ethyl acetate and butyric acid it is 2, and for paraldehyde and benzyl benzoate 3.

18. *Inorganic Salts.* The crystalline structures of more than 150 inorganic compounds are now established. These range in complexity from lithium hydride or rocksalt to uranyl nitrate hexahydrate, hexammine nickel chloride, or ammonium fluomolybdate and just now ammonium heptafluozirconate and heptafluohafniate. The importance of this information in every phase of science and industry cannot be overestimated.

19. *Organic Compounds.* The Braggs in England have been pioneers in the study of the constitution of organic compound crystals in which whole molecules are singly acting units in the space lattice instead of atoms. Now we know with exactness the actual length of long soap molecules (stearic acid is 39.6×10^{-8} cm.). The polarizing property of tartaric acid and its racemic forms are natural consequences of the arrangement of molecules in crystals. The fascination in these results lies in the fact that perfectly definite visualization of heretofore immeasurably small units, of valence, and of stereoisomerism is possible.

20. *Metals.* One of the most fruitful fields for roentgen-ray investigation of structures is that of the metals. As we ordinarily know metals, they are constituted of very small crystalline aggregates in random orientation. Working, rolling or drawing produces more perfect orientation and effects which may be exactly followed, thereby removing metallurgy from empiricism. Germany has taken the lead in founding an institute solely for the purpose of metallographic investigation by means of roentgen rays. The roentgen-ray method has resulted also in the production of single metal crystals of great size which have altogether different properties from the crystal aggregate metal. Professor Bridgman of Harvard now finds it possible to construct a galvanic cell from zinc alone, one pole being a single crystal, the other the aggregate.

21. *Alloys and Solid Solutions.* In the past two years more progress has been made in understanding the true constitution and structural changes in steels, brasses, bronzes and other common alloys, than in all the long history of these invaluable materials. Unerringly the roentgen rays have defined the allotropic modifications of iron, and the changes from one to another, the appearance of new compounds of definite composition, the limitations of solid solution within which lattice dimensions change linearly with percentage composition of the components, the ranges of instability, the necessary composition for a desired property of hardness, ductility, etc., the effect of working or annealing, the alternative substitution of one atom for another or the

interstitial entrance of one kind of atom into the lattice of another, and the shapes of atoms, some acting as spheres, and others, such as zinc, definitely elongated in one direction. The possibilities are limitless, the results invaluable theoretically and technically. Solid solutions and mixed crystals of the alkali and ammonium halides so studied have given important information upon the limitations of the mutual solubility of melts and upon lattice and atomic dimensions not otherwise possible to obtain.

22. *Technical Materials.* There are so few solids which are really amorphous under the searching scrutiny of roentgen rays that roentgen-ray analysis may be successfully used on a wide variety of technical materials—coal, leather, soap, starch, sugars, paper, textiles, rubber, paints and ceramics. Cellulose fibers have a crystalline structure which is maintained, though the lattice dimensions change, even when swelling in liquids has occurred. This swelling might easily be made the measure of the acidity of the solution or of the tensile strength of fabrics. Pure rubber has been recently obtained as crystals with apparently one molecule of C_5H_8 per unit cell. The nature of rubber fillers, the chemical or physical state of sulfur in vulcanization, or the general validity of the polymerization theories may all be ascertained. Glass and fused quartz may be tested for incipient devitrification, for even the slightest crystalline structure is revealed by roentgen-ray diffraction on the photographic plate. The advantage of this information in the production of fine lenses and mirrors is obvious. Structural changes in ceramics will at last be linked with definite chemical change. The differences between white lead paint prepared in different ways will be interpreted from the standpoint of the chemical identity of definite basic carbonates. Natural and cultivated pearls have distinctly different crystalline structures, the former giving circular diffraction rings and the latter patterns with hexagonal symmetry.

23. *Films.* We do not know just how thick a layer of definitely arranged atoms or molecules must be in order to produce detectable crystal diffraction patterns. Sir William Bragg has found that gold leaf, so thin that it becomes perfectly transparent upon heating, gives good effects. This bodes well for a successful attack upon absorption films, oriented surfaces in liquids, electrodeposited metal films, corroded surfaces and the structures of the surfaces of catalysts. This promising field is being subjected to intensive study under the writer's direction at the Massachusetts Institute of Technology.

24. *A New Method of Chemical Analysis.* Since even minute quantities of crystalline substances may be detected by roentgen-ray diffraction patterns characteristic for each, it is obvious that unknown pure substances or mixtures may be chemically analyzed, particularly if standards for the pure materials are available. Relative quantities may be judged from intensities. The method is limited inasmuch as true solid solutions do not, in all cases so far studied, yield new and characteristic lines but act as single entities. Valuable application is to be found in the distinction between true chemical compounds, solid solutions, mixtures or adsorption complexes; for example, purple of Cassius has a diffraction pattern to which both stannic hydroxide and gold contribute separately. Hence this beautifully colored substance is not a chemical compound but an adsorption complex. Mixtures of the rare earths are easily tested and identified. The long controversy as to the fundamental difference between the red and the yellow forms of lead oxide has been recently settled; the color does not depend upon different states of subdivision but upon clearly different crystal structures. On the other hand, the apparently greatly different hydrated tin oxides give precisely the same roentgen-ray diffraction patterns. Differential absorption of roentgen rays by matter, particularly by sheets of metal and alloy, might be employed for rapid analysis after known values for standard samples are established.

25. *Control of Precipitation.* One of the great problems in analytical chemistry is to obtain precipitates which may be easily handled. Many compounds readily precipitate in colloidal form and cannot be filtered. Under other conditions of temper-

ature and concentration distinct crystals may form. The dividing line between colloid and crystalloid is immediately established by the roentgen-ray powder diffraction method; the first produces no diffraction lines but the second does even in incipient formation. Similarly the processes of aging and coagulation of colloids may be followed step by step.

26. *Dimensions of Atoms and the Periodic Table.* Numerous attempts are being made to derive from the accurate data on the dimensions of crystalline unit cells, the constant size of atoms, and to establish the periodicity of size and of crystalline type. Certain basic assumptions are necessarily involved as, for example, that the potassium and chlorine atoms in potassium chloride have the same size because they have the same number of electrons. The data so obtained are interesting and valuable, but by careful analysis the fact is established that the hypothesis of constant atomic radii is not rigorously true. The size of the lighter atoms particularly seems to depend upon the nature of the compound in which they are combined.

27. *Refractive Index.* W. L. Bragg in some very new work has undertaken with success the difficult task of relating crystal structure to such properties as refractive index so that one may be inferred from the other. Extension to crystals other than calcite will be awaited with interest. As a matter of fact the only properties of solid bodies which are not directly and obviously related to crystal structure are those, few in number, which depend on atomic characteristics alone, such as weight.

28. *Secondary Valence.* Many years ago, Werner, in one of the classic works of chemistry, set about to explain the structure of such secondary valence compounds as $Ni(NH_3)_6Cl_2$, hexammine nickel chloride, in which six electrically neutral molecules of ammonia are bound by residual forces by a neutral molecule of nickel chloride. He maintained that the six ammonia molecules should be distributed at the corners of an octahedron around the central metal atom. Roentgen-ray analysis proves directly that this is actually the case as it is also in $Zn(BrO_3)_2.6H_2O$, K_2PtCl_6 and other compounds. The present writer has determined the structures of some of the alkali polyhalides, such as potassium or cesium triiodide, and found again that the identity of the complex acid ion indicated in solution is maintained as a single acting unit in the solid space lattice. The actual forces which enable these complex compounds to form, the sharing of electrons, singly or in pairs, may be adequately related to the very definite crystal structure information upon the basis of the Bohr theory, which will be considered a little later.

III. ROENTGEN RAYS AND ATOMIC STRUCTURE

29. *The Importance of Atomic Number.* Not only do roentgen rays have objective application directly and in the detection of crystalline structure, but they have subjective application to the inner architecture of those atoms which are producing the radiation itself. Every element used as a target against which is impinging a stream of cathode rays accelerated by a high voltage produces as a consequence roentgen rays with wave lengths which are characteristic of that element. When the spectrum is spread out by means of a crystal with a known grating or lattice constant, characteristic groups of emission lines appear. Moseley in 1914 discovered that if the square roots of the frequencies of these rays were plotted against the atomic numbers of the elements, straight lines result, and that this relationship is not true if atomic weights instead of numbers are substituted. This was splendid evidence of the essential continuity of structure in proceeding from hydrogen, number 1, to uranium, number 92, and of the fundamental importance of the atomic number synonymous with the number of nonnuclear electrons. The great value of roentgen spectra lies in the simplicity of the series as contrasted with optical spectra. The K series, for example, has only four lines for every element.

30. *Stokes Law.* Roentgen rays verified completely the law that fluorescent characteristic radiation can be excited only by primary rays of the same or shorter wave lengths. We know, however, that the four

K lines always appear together and must be excited by energy somewhat greater than that corresponding to the "hardest" of the four.

31. *Atomic Models—The Bohr Theory.* The science of roentgen rays has had since 1913 the great aid of the Bohr theory of atomic structure which was presented to the world in the attempt to correlate the seemingly hopeless impasse between the empirical optical spectroscopy of Balmer, Ritz and Rydberg, the quantum theory of Planck, the nuclear atom of Rutherford, and the classical electrodynamics of Maxwell and Lorentz. Bohr conceived of the atom as a positively charged nucleus around which were rotating in orbits a number of electrons corresponding to the atomic number. These orbits represented definite energy levels or steady and non-radiating states, while radiation was emitted only during the transition of an electron from one orbit to another of lower energy, or absorbed in the transition to a higher energy level. While this theory successfully predicted and adequately explained the results of roentgen-ray spectroscopy, at the same time experimental roentgen-ray spectroscopy has been one of the powerful supports of the theory, assisting in its development and strengthening its postulates until now the Bohr theory is generally accepted by the physicist and chemist alike to explain both the facts of spectroscopy and of chemical valency. Radioactivity and the epochal experiments of Rutherford in bombarding hydrogen out of atoms of all the elements from boron to potassium, except carbon and oxygen, give us experimental insight into the nuclei of atoms. Chemical reactions and optical spectroscopy give us information as to the outermost constitution of atoms. Upon roentgen rays must rest very largely the responsibility for our knowledge of the inner electrons, those in the innermost K ring, the second L ring with its three energy levels, the third M ring with its five levels, and so on out. In Figure 1 is shown the Bohr conception of the radium atom. Upon this scale the nucleus is too small to be shown even by a dot. The circles and ellipses represent the electrons orbits, 88 in all.

32. *The Combination Principle.* One of the great strengths of the conception of the production of characteristic roentgen rays by interorbital transitions is the truth of the combination principle. If the Kβ line is produced by a transition from the M to the K ring, then its frequency should, upon this principle, be equal to the sum of the frequencies of the Kα line (from L to K) and the Lα line (from M to L). The principle is rigorously checked by the experimental values.

33. *The Discovery and Identification of New Elements.* The simplicity of roentgen-ray spectra and of the relationship between frequencies and atomic numbers has predicted and triumphantly identified hafnium, element number 72. The minutest traces of the still unknown 43, 61, 75, 85 and 87 in minerals should disclose themselves as characteristic emission lines or absorption discontinuities. All have been sought, but so far without success. It may be confidently predicted that if these elements do exist in matter to which man has access, they will be discovered by the roentgen-ray method. Only by this method has it been possible finally to straighten out the great enigma of the rare earths; for in passing from one to the next of these closely related elements electrons are added, not in outer shells, but to inner incomplete ones until once more the usual progression is again re-established.

34. *The Number of Electrons in Atoms and the Existence of Ions and Atoms in Space Lattices.* From scattering experiments, together with Thomson's classical equations, Barkla many years ago found that the number of electrons is equal to half the atomic weight. This is true for the lower atomic numbers, but departure from the classical conditions of non-cooperation of electrons in roentgen-ray scattering renders the relationship less and less accurate with higher atomic numbers. The intensities of reflection of characteristic lines is also a medium for evaluation of the number of electrons. Upon this basis Debye declared that lithium hydride in its lattice was composed of lithium and hydrogen ions. Recent work throws considerable doubt upon the general truth of this observation. Professor Bergen Davis of

Columbia University has made the interesting discovery that experimental results on refraction of roentgen rays in pyrites and other crystals when applied in the dispersion formula of Lorentz give values for the number of electrons in various levels which are the same as postulated by the Bohr theory.

35. *The Quantum Theory.* The Bohr theory of atomic structure and of the production of radiation has the quantum theory or the discontinuity of energy changes as a foundation stone. The combination principle substantiates it. Even more direct evidence of its validity is contributed by roentgen rays; for the short wave-length limit of the general radiation from a target is absolutely sharply and perfectly defined by the quantum equation $Ve = h\nu = hc/\lambda$ where V is the voltage applied to the roentgen-ray tube, e is the charge of the electron, h is Planck's action constant, ν the frequency, c the velocity of light, and λ the short wave-length limit. Furthermore, the phenomenon of interference in reflection from crystals, long considered possible only upon the wave theory conception, is now explained by Professor Duane of Harvard upon a quantum basis by quantizing radiation momenta transferred to matter. The great controversy between proponents of the classical electromagnetic theory and those of the quantum theory still rages with the present tendency towards uniting the old and new theories and casting out bodily the discrepancies. Two years ago A. H. Compton announced a theory of the scattering of roentgen-ray quanta by single electrons, which recoil resulting in the probability that the scattered roentgen ray has less energy by the amount involved in the recoil and hence a longer wave length than the primary. This has been disputed by Clark and Duane who were unable to obtain evidence of the shift, but did discover tertiary roentgen rays produced by the impact of secondary photoelectrons on neighboring atoms whose short wave-length limit again is governed strictly by quantum laws. Much experimental work remains to be done relative to details, but the validity of the so-called "bullet" conception of radiation seems well established largely through the facts of researches with roentgen rays.

36. *Relativity.* The fine structure of roentgen-ray spectra, for example, the L-doublets, agrees with theoretical considerations based upon the relativity theory. The change in mass of the electron with velocity is a generally accepted fact in all mathematical derivations.

37. *The Nature of Light.* Since the beginning of man's life on earth light has been recognized. Through the centuries philosophers pondered over it, mathematicians calculated it, physicists experimented with it. Now we find ourselves working backwards from the thirty-year old science of roentgen rays to try to explain it—to interpret its structure and to trace its origin. There are now almost no experimental gaps at all in the long continuous series from the very long electric waves to the very short γ-rays from radioactive substances.

The kinship is shown in the following table, in which the first column presents the type of radiation, the second the frequency of vibration per second, the third the wave length, the fourth the quantum voltage required for generation and the fifth the speed of the photoelectrons ejected from matter as a result of radiation impact.

Radiation	Frequency (Sec. $^{-1}$)	Wave Length	Quantum Volts	Speed Photo-electrons cm./sec.
Electric....	10^6	3×10^4 cm.	4.1×10^{-9}	3.8×10^3
Infra-red..	10^{12}	$3 \times 10^{-3} = 30\mu$	4.1×10^{-3}	1.2×10^7
Yellow.....	5×10^{14}	$6 \times 10^{-5} = 0.6\mu$	2.06	8.5×10^7
Extreme ultraviolet	3×10^{15}	$10^{-5} = 0.1\mu$	12.4	2.1×10^8
Very soft roentgen rays.....	3×10^{17}	$10^{-7} = 10\text{Å}$	1240	2.1×10^9
Roentgen rays.....	3×10^{18}	$10^{-8} = 1\text{Å}$	12400	
Hard roentgen rays..	3×10^{19}	$10^{-9} = 0.1\text{Å}$	124000	Approach light
γ-rays.....	10^{21}	10^{-3}Å	10^6	Approach light

Thus we have reviewed thirty-seven, by no means all, of the achievements of the peculiar radiation discovered one day in the autumn of 1895 by Röntgen in his darkened laboratory when his eyes beheld a barium platinocyanide screen strongly luminescent. We have seen much of this mystery become clear fact under the hands

of Barkla, Laue, the Braggs, Moseley, who fell for his England in the Dardanelles, Siegbahn and all the other experimenters, who, bit by bit, have built up our present knowledge. Who would have dreamed in 1895 that in 1924 great hospitals, dental laboratories, government arsenals, university departments of physics, chemistry, engineering, metallurgy, biology, and medicine, factories producing sulfuric acid, or sheet metal, or paper, or bridges, or automobile tires, or chemicals, customs houses, detective agencies—all would have roentgen-ray laboratories working at top speed? Whither shall the science of roentgen rays have led us in another thirty years?

THE FIRST YEAR!

STRICKLAND V. GILLILAN winds up his "prefatory soliloquy" to his famous book of verse, "Including Finnegan," with the statement: "Anyone can see in a moment that my association with my wife and my children has been one of the most fruitful inspiration sources. They are my mainspring. Were it not for them, I couldn't work so much—and I shouldn't need to, either."

At the end of the first year of editorial duties we have somewhat this feeling toward our subscribers. Were it not for them we could not work so much—and we shouldn't need to, either. The authors, the editor and the publishers produce the Journal, but its value consists not in its production but in its use. In the final analysis, therefore, it is *you*, the classic "gentle reader," who determines the success of any publishing enterprise.

We point with some pride to the fact that the circulation of THE AMERICAN JOURNAL OF ROENTGENOLOGY AND RADIUM THERAPY in December, 1924, is *the largest in its history*, a fact that is most encouraging and stimulating. Our duties were undertaken a year ago in considerable trepidation. A high standard had been set by the former editors, and the orders were, "Enlarge and improve." No easy task! But the attempt was made whole-heartedly and we are encouraged to believe that our efforts have not been entirely unsuccessful.

That our goal has been reached is not to be considered for a moment. That steps forward have been made, is a claim modestly put forth. Plans for continued development are constantly in mind.

The editor appreciates the kindly comment and criticism of a constructive nature which he has received. The remarks have not always been flattering or approving, and perhaps those with suggestions for changes were the most valuable. We want to produce a journal that fits *your* needs. You can help us. If you like the JOURNAL as it is, say so occasionally; it won't make us conceited. But, more important, if you don't like it or if you find something lacking, tell us about it in detail. The editor will sincerely thank you for the trouble you have taken, and we shall all profit by your cooperation.

Above all, we want our readers, whether members of The American Roentgen Ray Society or not, to realize their importance in the development of this, *the roentgenologist's own Journal*. Quote it, talk about it and recommend it! The more you do for us in this direction, the more we shall be able to do for you. Cooperation has been the keystone of the success of the JOURNAL. Without it all our efforts would be unavailing. With increased circulation and more advertising, we shall have to work more, and the more we work the more circulation and advertising we shall need. With *your* active, continued and increased support, further success is assured.

It will interest our American readers to know that the JOURNAL has an extensive and growing subscription list in foreign countries. From all over the world come the highest encomiums on our JOURNAL. Its circulation is today the largest ever achieved by a roentgenological journal, not only in America, but abroad. This is a compliment from our readers overseas which we appreciate and accept as a stimulus to increased endeavor.

Our first year is over. Plans for 1925 are under way.

We wish you all a Happy New Year!

SOCIETY PROCEEDINGS, CORRESPONDENCE AND NEWS ITEMS

Items for this column solicited promptly after the events to which they refer.

AMERICAN ROENTGEN RAY SOCIETY

SIXTH ANNUAL MEETING,
EASTERN SECTION
CHALFONTE-HADDON HALL, ATLANTIC CITY, N. J.
JANUARY 22, 23, 24, 1925
PRELIMINARY PROGRAM

THURSDAY EVENING, JANUARY 22

"The Relation of Roentgenology to Urology, with Demonstration of Methods." By DR. HUGH H. YOUNG (by invitation) Baltimore, Md.

FRIDAY MORNING, JANUARY 23

1. "The Roentgen Treatment of Brain Tumors." By DR. GORDON E. RICHARDS, Toronto, Canada.
2. "The Roentgen Treatment of Hemorrhagic Purpura." By DR. HENRY K. PANCOAST, Philadelphia, Pa.
3. "The Roentgen-Ray Treatment of Chronic Spondylitis Deformans, Chronic Sacro-iliac Lumbalgia or Chronic Vertebral Rheumatism." By DR. CHARLES A. PFENDER, Washington, D. C.
4. "Epilation in Mice as a Biological Standard for Determining Roentgen-Ray Dosage" (Preliminary Communication). By DRS. HENRY H. HAZEN, EUGENE R. WHITMORE and LAURENCE C. MILSTEAD, Washington, D. C.
5. "Is Radiation a Satisfactory Treatment for Substernal Thyroid?" By DR. G. W. GRIER, Pittsburgh, Pa.
6. "The Effect of Radio-therapy upon the Metastatic Lymphnodes of Mammary Cancer." By DR. BURTON J. LEE, New York City.
7. "Further Remarks on the Diagnosis and Treatment of Bone Tumors." By DR. R. E. HERENDEEN, New York City.

FRIDAY AFTERNOON, JANUARY 23

1. Paper by DR. GEORGE W. HOLMES, Boston, Mass. Subject to be announced.
2. Paper by DR. JAMES WILSON HUNTER, Norfolk, Va. Subject to be announced.
3. "A Chest Clinic for Medical Students." By DR. A. H. PIRIE, Montreal, Canada.
4. "X-ray Treatment in Surgical Tuberculosis." By DR. ISAAC GERBER, Providence, R. I.
5. "Report of Two Cases of Syphilis Mutilans." By DR. P. M. HICKEY, Ann Arbor, Mich.
6. "Subphrenic Abscess; Differential Diagnosis." By DR. LEON T. LEWALD, New York City.
7. "Diaphragmatic Hernia." By DR. T. R. HEALY, Boston, Mass.

FRIDAY EVENING, JANUARY 23

1. "Cinematographic Study of Gastric Ulcer." By DR. LEWIS GREGORY COLE, New York City.
2. "Non-opaque Foreign Bodies in the Trachea." By DR. WILLIS F. MANGES, Philadelphia, Pa.
3. Lantern Slide Exhibit.

SATURDAY MORNING, JANUARY 24

1. "A Study of the Kidneys and Ureters." By DR. DOUGLAS J. ROBERTS (by invitation) Hartford, Conn.
2. "The Precise Roentgenography of the Optical Canals." By DR. H. A. GOALWIN, New York City.
3. "A New Device for Drying Films." By DR. GEORGE E. PFAHLER, Philadelphia, Pa.
4. "Further Experience with the Use of Tetrabromphenolphthalein Sodium Salt in the Diagnosis of Gall Bladder Disease." By DR. W. H. STEWART, New York City.
5. "Protection of the Roentgenologist against the Law Hazard in X-ray Therapy." By MR. GEORGE W. WHITESIDE (by invitation) New York City.

REPORT OF THE SAFETY COMMITTEE OF THE AMERICAN ROENTGEN RAY SOCIETY*

THE 1922 report of the Committee discussed the dangers arising from the high potential currents produced by modern roentgen-ray equipment and the necessary installation of commercial circuits capable of sustaining heavy loads required for operating such apparatus, and contained certain recommendations to eliminate these dangers as far as possible.

In connection with this report the Committee urges that instructions be placed upon the walls of laboratories for the care of patients in case of electric shock.

The 1923 report discussed, (1) the possible injuries arising from excessive roentgen-ray and radium-ray exposure of patients, operators and attendants, and made certain protective recommendations; (2) some phases of radiation sickness from the standpoint of dosage; and (3) it included a review of the literature on these and allied subjects.

The Safety Committee has held two meetings during the past year. The first followed immediately after the Eastern Section meeting at Atlantic City in Jan-

* Presented at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

uary, at which meeting the program of future work was outlined. The second meeting was held at Buffalo, April 16, 1924, with full attendance. It was realized that a large part of the pioneer and important work of this Committee had already been accomplished, and there remained for the most part the settlement of the minor details of the subjects already discussed. Some of the unfinished investigations of the previous year have received attention; certain new dangers which have recently arisen have been discussed, and recommendations will be made; and the Committee has, on one or two occasions, acted in an advisory capacity to the Society and its members upon certain matters pertaining to safety problems. Furthermore, the assistance of scientific bodies outside of the Society has been sought for the purpose of carrying out experimental work to the best advantage.

The following topics have been discussed by the Committee during the past year:

1. The estimation of stray radiation in roentgen-ray laboratories.
2. The standardization of protective materials.
3. The estimation of the limit of safety to exposure by roentgen-ray and radium workers.
4. Blood changes in roentgen-ray and radium workers.
5. The film and fire hazard.
6. Barium poisoning.
7. Efficiency of contact breakers.
8. Protection of tube ends.

1. *The Estimation of Stray Radiation.* One of the unfinished problems reported by the Committee last year was the estimation of stray radiation in roentgen-ray laboratories at various distances and with different wave lengths. It was thought best this year to turn the experimental work and the development of the practical side of the problem over to the United States Bureau of Standards. An appeal was made to the Bureau to take up this work in order to develop some practical apparatus for the detection and measurement of stray radiation so that some time in the near future each of us would be able to measure the amount of exposure to which we are being subjected in our treatment control, roentgenographic and roentgenoscopic rooms. The Bureau of Standards has replied that this represents exactly the type of work which they believe they should undertake, and they hope eventually to cooperate with us in every way in such problems; unfortunately they are not in a position to do so at present. They have started a roentgen-ray laboratory but have only low voltage apparatus for working with roentgen-rays of the longer wave lengths. They are about to start investigations of secondary radiation arising from such wave lengths, which apply particularly to our roentgenoscopic work, but are going ahead with the designing of the apparatus necessary for the production of shorter wave lengths. In another year they hope to have the funds available for the purchase of the necessary equipment and the employment of additional help.

In the meantime, in order to keep pace with the steady increase in the possibilities of excessive bodily exposure, we should ourselves adopt some uniform method of rough estimation of the amount of exposure each individual worker is receiving. In connection with deep therapy we must consider the possibility of exposure from both direct and stray radiation.

It is assumed that the operators and patient are fully protected against direct high voltage short wave length exposure by the tube holder, although any possibility of leakage should receive careful attention. In setting up apparatus, manufacturers are urged not to point the tube target toward the control room. It is encumbent upon us to guard against the possibility of exposure of other individuals in the same or adjoining buildings, especially those remaining in more or less permanent positions on the floor above or below the operating tube. Careful tests should be made to ensure adequate protection from any exposure of this kind.

Our greatest danger lies in the stray radiation of a similar order of wave length coming from the patient, protective coverings over the patient and the walls and objects in the treatment room. We should realize the possibility of rays scattering in

different directions or angles. For example, incomplete protection through some part of the control room wall may permit stray radiation to pass through, strike the wall back of the operator, whence it may pass to the operator.

By this time we should have fully realized the importance of protecting ourselves against direct and stray radiation during roentgenographic exposures, and have acted accordingly. Perhaps the greatest act of carelessness is the exposure of attendants who are making stereoscopic plate shifts on Potter-Bucky tables and chest stands.

Undoubtedly a large number of individuals are receiving too much exposure during roentgenoscopy, mostly from stray radiation from the patient or direct or stray radiation upon the hands when making manual manipulations. All roentgenoscopic rooms should be thoroughly tested by methods suggested later on, and the protection necessary to eliminate all but an unavoidable minimum of exposure instituted. This can be done, but a most thorough search for leakage is essential.

The problem of qualitative and quantitative estimation, in a practical way, of unwarranted exposures such as have been enumerated has been left for the Bureau of Standards to solve for us. In the meantime, all of us have at our command very simple means of roughly determining the existence of leakage. The simplest way is by the use of the roentgenoscope during absolute darkness. If any light is present in the room, the hooded instrument should be used after the eyes have become thoroughly accustomed to darkness. In this manner it is possible to detect exceedingly small amounts of radiation. It is strongly urged that every roentgen-ray and radium worker employ this method throughout his laboratory, and if the slightest illumination of the screen should be observed during absolute darkness, steps should at once be taken to measure the intensity and eliminate this source of exposure, especially in treatment control rooms.

The placing of dental films in various parts of the rooms or on the individual is a method that has long been in use for detecting cumulative amounts of radiation. When worn on the person, films should be placed over several portions of the body. For example, a film left in the lower vest pocket may show little or no exposure after several days, whereas another worn in the upper vest pocket or on the back may show much exposure in the same length of time.

The following method of quantitative determination has been suggested to the Committee by the physicist in one of the large therapeutic institutions of the country, and is quoted as a means of affording suggestions: "The films (all of the same speed emulsion and age) after exposure should be developed at a standard time and temperature in a standard developer and fixing bath, and washed the same length of time, and all dried in the same manner. Their degree of blackness should then be compared with a series of similar films exposed to roentgen radiation of known intensity and practically the same wave length, each one being calibrated in terms of an erythema dose, roentgenographic exposure or other arbitrary unit. The following example is given as a means of standardizing a film under direct radiation from a treatment tube: The film is placed upon a block of beeswax in a 20 × 20 cm. field at the usual skin target distance of 80 cm., and under the usual voltage and filtration, and exposed 1 second with 2 ma. The other erythema dosage factors for that apparatus are 200 kv., 8 ma., 80 cm. skin target distance, 0.5 mm. copper filter and 100 min. The proportion of an erythema dose represented by the degree of blackening of the film at 1 second exposure with 2 ma. of current would be represented by the formula $\frac{1}{4 \times 100 \times 60}$." The time can, of course, be varied on several control films. This experimental standard applies accurately, of course, only to rays of the order of wave length active under the conditions enumerated. Probably separate standardization will be required for fairly accurate measurements of the softer stray radiation arising from the use of tubes employed in roentgenoscopic and roentgenographic work.

If comparative photometric measurements of film exposures could be made for

all operators at some central laboratory, it would be a great service and convenience to all of us. The Eastman Company has been approached with a view of having them undertake this, and while they have expressed a willingness to cooperate in every way with the Committee in the measurement of films exposed to determine the safety of typical installations, they cannot see their way clear to do this for everyone interested in this sort of problem. They had offered the following suggestion which may be of value: "An Extra Fast dental film would acquire a *noticeable* fog density in slightly less than 0.08 ma-sec. at a 10-in. distance, using a 5-in. gap. Compared with Dr. Erskine's figures given in the AMERICAN JOURNAL OF ROENTGENOLOGY for March, 1922, for a minimum erythema dose, which he states to be about 800 ma-sec. at 10 in., 5-in. gap, 1 mm. Al filter, this gives a ratio of about 1 to 1,000."

2. *The Standardization of Protective Materials.* The protection against dangerous exposure is largely a matter of the use of adequate protective materials. We have become accustomed over a period of years to depend upon lead for this purpose, and to compare the efficiency of other protective materials in terms of lead. When this metal is employed, safe protection is simply a matter of adequate thickness of lead, but necessity has required the use of other materials, such as lead rubber, lead glass, barium plaster and bricks and other metals and alloys in many instances. Such materials are purchased from manufacturers, and not only is there no standard of efficiency, but we have no way of readily determining exactly what the efficiency may be. The Committee has felt that the matter is unquestionably one that should be under federal control, and that the obvious and logical agent for standardization is the Bureau of Standards. With their supervision, the manufacturers and dealers would be more likely to deliver more uniform materials which would be sold under some standard unit of protection and with the equivalent stamped upon the materials. The Bureau has again expressed its willingness to cooperate in this matter. As they were not equipped with high voltage apparatus, we thought it wise to first determine at what voltage such materials had best be tested, and whether a high, low or any uniform voltage would answer the purpose. This determination was placed in the hands of Dr. Bernard H. Nichols, who has furnished the Committee, and through us the Bureau of Standards, with the following results of his investigations:

"The work was done by the physics department of the Cleveland Clinic with 200 kv. and 100 kv. respectively. The final determination was made by using two sheets of commercial lead glass, one 6.2 mm. in thickness and the other 6.1 mm. in thickness. Small portals of entry were used, and the results checked by ionization chamber measurements, with the following results:

"Lead glass No. 1, 6.2 mm. thickness, measured with 200 kv. was found to be equivalent to 1.4 mm. lead.

"Lead glass No. 2, 6.1 mm. thickness, measured with 200 kv. was equivalent to 0.45 mm. lead.

"Lead glass No. 1, 6.2 mm. thickness, measured with 100 kv. showed a protection equivalent to 1.55 mm. lead.

"Lead glass No. 2, 6.1 mm. thickness, measured with 100 kv. was equivalent to 0.51 mm. lead.

"The conclusion from these experiments is that in determining the lead values of these various glasses 200,000 volts or more are necessary."

This information has been furnished to the Bureau of Standards by the Committee.

3. *The Estimation of the Limit of Safety to Exposure.* The Committee was desirous of determining some estimate of the amount of roentgen radiation that an operator could stand continuously with a reasonable degree of safety, in connection with roentgenoscopic, roentgenographic and both deep and lower voltage therapeutic work. In this connection, it might also be valuable to determine something of the roentgen-ray intensity to which the older men in the work had been exposed, and how this might compare with the total amount now regarded as safe over a number of years. This matter has also been referred for possible solution to the Bureau of Standards.

4. *Blood Changes in Roentgen-ray and Radium Workers.* The Committee has taken up the question of changes in the blood of operators that might be regarded as danger signs, but we have been unable to gather any information on this subject beyond the little that has appeared in the literature.

5. *The Film and Fire Hazard.* At the last annual meeting this matter was informally brought to the attention of the Committee for consideration. The almost universal use of films for roentgenographic purposes during the past few years has created a situation of very definite danger from fire and explosion in roentgen-ray laboratories and offices where large numbers of films are stored. Until quite recently, all roentgenographic films were coated upon a cellulose nitrate base, which is not only highly inflammable, but which during combustion, and even at temperatures too low for complete combustion, generates gases which are both irritating and explosive. The fire hazard is in many respects comparable to that of the moving picture industry. The fire dangers arising from film storage have already been demonstrated in a number of actual instances. There is an effort on the part of some film manufacturers to substitute a cellulose acetate for the cellulose nitrate base, producing a film, which, while it will burn readily like paper when ignited, is apparently free from the dangers of gas production, especially of an explosive nature.

As the authority of local Boards of Fire Underwriters supersedes that of this Committee, we feel that we are not in a position to dogmatize in this matter, and that the solution will have to be a matter for adjustment between roentgenologists and their local Boards of Fire Underwriters. With full realization of the dangers from film storage, each of us should be quite willing to cooperate toward an amicable adjustment of a matter which must be settled in every locality in the very near future. Pending such adjustment, the Committee advises that films be stored in as nearly fireproof rooms as possible, that smoking and lighting of matches in such rooms be absolutely prohibited, and that no films or scraps be placed in waste paper baskets or other receptacles into which matches or lighted cigarettes or cigars might be thrown or the contents of which might be put into incinerators for destruction.

6. *Barium Poisoning.* The fact has been brought to the attention of the Safety Committee that several deaths have occurred throughout the country during the past few years because of soluble barium salts being substituted for insoluble barium sulphate, and especially prepared barium sulphate, in the preparation of patients for roentgen-ray examinations of the digestive tract. Barium sulphate is a substance which is seldom in prescriptions and seldom called for by individuals in drug stores. On the other hand, barium sulphide is a well known depilatory, easily obtained from any drug store, and is extremely poisonous when taken internally. In order to avoid any possibility of mistakes occurring in the future, it is suggested by the Safety Committee that no prescriptions be written for barium sulphate and that patients should not be instructed to obtain this substance from drug stores. Bismuth subcarbonate will answer the purpose just as well and there is not the same element of danger in writing a prescription for bismuth subcarbonate. It is, of course, perfectly proper to use barium sulphate in roentgen-ray laboratories, in institutions and in private offices of roentgenologists, where the substance is bought in bulk and for roentgen-ray purposes.

The Committee has requested that notices to this effect be published in the American Journal of Roentgenology and the Journal of the American Medical Association. The attention of the National Association of Retail Druggists has also been called to this matter, and they have promised to give it prominence in their journal.

7. *Efficiency of Contact Breakers.* Many instances have been brought to the attention of the Committee of the failure of action, through sticking from arc welding or other causes, of contactors on the main primary circuit operated by remote control such as push buttons or time switches. As a result of such sticking the high tension voltage is left on the tube system until a main switch can be opened, and in the

interval, the operator, having supposedly opened the primary circuit by the push button or time switch, may be under the impression that the high tension circuit is dead. In addition to this danger, there is the inconvenience of spoiling the exposure and possible damage to the tube. To obviate this situation, the Committee recommends, first, that the manufacturers shall install contactors so that they will not stick under the duty in question, and, second, that the main primary switch shall be convenient to the operator.

8. *Protection of Tube Ends.* The Committee takes this opportunity of again urging that some protective guard be placed about all tube terminals to prevent actual or too close contact of these parts of the tube with the patient.

Henry K. Pancoast, M.D.,
Chairman,
Philadelphia, Penna.
Preston M. Hickey, M.D.,
Ann Arbor, Mich.
William D. Coolidge, M.D.,
Schenectady, N. Y.
William Duane, M.D.,
Boston, Mass.
John T. Murphy, M.D.,
Toledo, Ohio.
Bernard H. Nichols, M.D.,
Cleveland, Ohio.

A QUESTION OF PRIORITY

Editor,
The American Journal of Roentgenology and Radium Therapy.
Dear Sir:

We notice in the September issue, page 271, of the American Journal of Roentgenology and Radium Therapy, an article entitled, "A Practical Method of Constantly Measuring the Radiation from a Roentgen Tube with a Check against the Omission of Filters," by J. L. Weatherwax, M.A., and E. T. Leddy, M.D.

We read this article with great interest and are pleased to make you aware that the "condenser type of ionisation chamber," constructed by these gentlemen, is exactly similar to our device called "Intensionomètre," which was patented in France on the 17th of July, 1922, under the No. 554,001, which we have industrially constructed and sold for a rather long time, as you can see by the pamphlets we send you attached herewith.

We do not intend to cross in any way the authors of your article, but would have been pleased to be mentioned in their references, as our device has been known in the United States since 1922.

We hope you will agree with our request, and meanwhile we beg to remain,

Yours faithfully,
Gaiffe-Gallot et Pilon.

Paris, France,
October 11, 1924.

Editor,
The American Journal of Roentgenology and Radium Therapy.
Dear Sir:

We thank you very much for calling our attention to the fact that a device for measuring roentgen-ray intensity similar to that described by us in the September issue of the American Journal of Roentgenology and Radium Therapy was previously described in France. In our review of the literature describing the various ionization measuring systems in use, we did not find a reference to the so-called "Intensionomètre."

Both of these systems are fundamentally the same in that they consist of a condenser type of ionization chamber connected to a galvanometer differing from the Duane system only in details of construction. The condenser type of ionization chamber is not original with us, or the "Intensionomètre" as this is an old, well-known method of constructing ionization chambers. Systems involving this principle have been in use for years both in this country and abroad, and we make no priority claim in the construction of our apparatus, as references were made to Duane and Failla, who have constructed similar measuring devices. In other words, we applied well-known principles to the construction of an apparatus designed both as a measure and a safety device in recording roentgen-ray intensity, and are not at present in a position to determine to whom belong the

priority rights in the construction of such a device.

Thanking you again, we are

Yours very truly,
J. L. Weatherwax,
Eugene T. Leddy.

Philadelphia, Penna.
October 30, 1924.

"INDEX RADIOLOGORUM"

The following communication has been received from Dr. J. Wetterer of Mannheim, Germany. It is commended to the attention of our readers:

INVITATION

For the foundation of the "Index radiologorum"
(International Register of Radiologists and Electrologists)

More than the representatives of other branches of science radiologists need a close alliance among themselves. The rapid course of development which the researches in radiology and electrology uninterruptedly pursue, necessitates the keeping in touch and the insuring of strong support both scientifically and socially.

The "Index radiologorum" is designed to be not only a register of addresses, but it aims at higher ends:

It will throw light on the state of radiology in the various countries in the form of a large number of valuable original contributions:

It will become a guide to the academic centres of medical radiology;

It will regulate the insurances of radiologists on an international basis;

It will assist talent, provide stipends of meritorious men of this profession;

It intends to support families of radiologists, fighting the battle of life, and, last but not least;

It is destined—according to the excellent proposal of Dr. Regaud—to help to facilitate the exchange of literature between the radiologists of the whole world.

The fund which is to be created from the sale of the Index-volumes, the advertisements and the subscriptions, will in the beginning probably yield only modest means with which to realize the numerous plans above put forth. But later on these means will surely grow, as only the running expenses (even though they are high) and those of the administration come into question, and as any personal gain is strictly excluded.

The due administration and application of the fund will be under the supervision of the grand committee of the Authors—Protectors, who in most kind response to the invitation of the founders put themselves at their disposal to act as the representatives of the various countries. They will be assisted by a trustee.

For the present the principal point is that if possible all radiologists become members of the international Index.

Every medical man, be he radiologist by his principal or his secondary calling, is kindly requested, to enter his name in one of the lists, which will shortly be inclosed in the medical journals under the title "Index radiologorum" and to send in the subscription with the fee therein, which is kept as low as possible.

The larger the number of subscribers the larger the means will be for the Index to operate with.

DR. WETTERER.

Mannheim, Germany.

DEPARTMENT OF TECHNIQUE

Department Editor: DAVID R. BOWEN, M.D., Pennsylvania Hospital, Philadelphia, Pa.

In this department will be published from time to time, as material is available, suggestions for improvement in technique.

TECHNIQUE FOR THE ROENTGENOLOGIC EXAMINATION OF THE NASAL ACCESSORY SINUSES*

BY JOSEPH ASPRAY, M.D., AND FREDERICK K. HERPEL, M.D.

SPOKANE, WASHINGTON

THE value of the roentgen examination of certain of the nasal accessory sinuses, namely the maxillary and frontal sinuses, is admitted by most rhinologists. A certain value is likewise admitted in the examination of the anterior group of the ethmoid cells. In the examination of the posterior ethmoid and sphenoid sinuses, however, the majority of rhinologists do not place sufficient confidence in the roentgenographic report. It is probable that their confidence has been undermined by conflicting and inaccurate reports, based in many instances on an incomplete examination. Others have expected the roentgen examination to tell them more than they have a right logically to expect.

Although we appreciate the difficulties of roentgenographic examination of the posterior and anterior ethmoids and the sphenoids, we nevertheless believe that a thorough roentgenologic examination and correct interpretation will place the roentgen diagnosis of diseases of these sinuses on a par with that of the frontal and maxillary sinuses.

Considerable experimental work on the dried skull and upon living subjects led us to the adoption of a routine technique for examination of the nasal accessory sinuses which we believe has certain advantages and superiorities which justify its presentation. The excellent experimental and clinical work of Granger, which has called the attention of the medical profession to some of the possibilities of diagnosis by the roentgen ray in affections of the posterior ethmoid and sphenoid sinuses, has given a decided impetus to investigation along these lines. The techniques of Granger, Law, Grier and others have been carried out in our laboratory and compared with our technique. We have as a result found no technique as a whole which appears to give us the information we routinely obtain in our sinus examinations.

It is not within the province of this paper to go into a discussion of the embryology and the detailed anatomical structure of the nasal accessory sinuses. It does appear, however, that there are certain anatomical features of the sinuses which should again be presented. We are indebted to Schaeffer's excellent work for information on the anatomical structure and development.

Frontal Sinuses. The frontal sinus may not be demonstrable at birth, but by the eighteenth to twentieth month it has usually invaded the vertical portion of the frontal bone. By the middle of the third year the cupola of the frontal sinus is above the level of the nasion. The growth of the frontal sinus may be almost entirely into the horizontal process of the frontal bone, and only slightly or not at all into the vertical process. From the outset the frontal sinuses vary markedly in size and shape. They are usually asymmetrical. The sinus may rarely be completely absent, but is often unilateral or rudimentary.

Maxillary Sinus or Antrum. This sinus conforms more often to a general type, and does not present the variations in structure which are found in the frontal sinuses. The growth of the maxillary sinus is rather uniform and the first dentition has little to do with any rapid increase in the size of the cavity. The adult maxillary sinus, located in the superior maxillary

* Read at the Twenty-fifth Annual Meeting, AMERICAN ROENTGEN RAY SOCIETY, Swampscott, Mass., Sept. 3–6, 1924.

bone, lies lateral to the nasal cavity, and resembles in shape a three-sided pyramid, with a roof, a floor and three walls. The walls vary considerably in thickness. In examining a roentgenogram of the maxillary sinus one must always keep in mind the possibility of the sinus being divided by septa into subcompartments, often of considerable depth. Drainage of the main cavity may not result in drainage of the subcompartments.

the field between the medial surfaces of the body orbits and, generally speaking, extends between the frontal sinuses ventrally and the sphenoidal sinuses dorsally. Above, the cribriform laminae serve as the boundary planes, while the uncinate processes represent the inferior limits of the ethmoidal labyrinth. Almost constantly the ethmoidal cells extend beyond the true limits of the ethmoidal field, and are known as ethmoido-frontal, ethmoido-max-

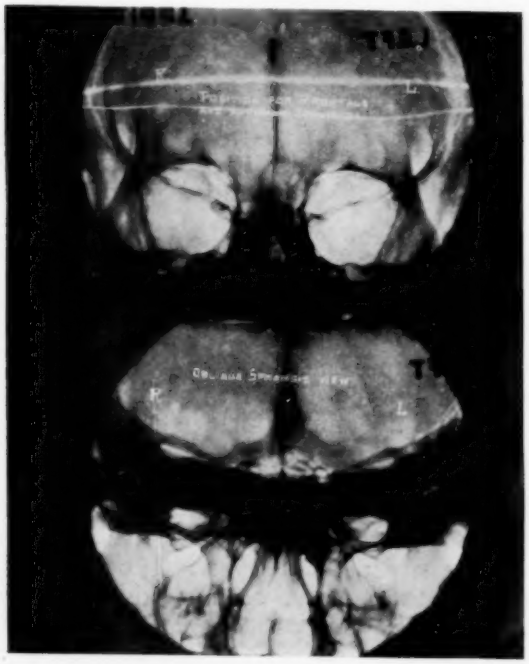


FIG. 1. Sinus technique. Dried skull experiment, with left posterior ethmoids and right sphenoid filled with bismuth paste. Position for anterior ethmoids and frontals (top), and position for posterior ethmoids and sphenoids, oblique posteroanterior view (bottom).

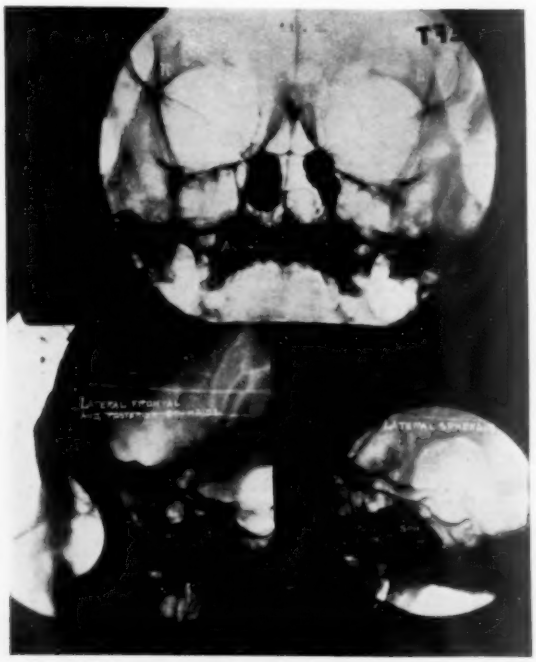


FIG. 2. Sinus technique. Dried skull experiment, with left posterior ethmoids and right sphenoid filled with bismuth paste. Position for antra (top), and lateral positions for frontals and posterior ethmoids and sphenoids (bottom).

Anterior and Posterior Ethmoids. In a general way the anterior group of ethmoid cells develops ventral to the posterior group. There is, however, at times considerable overlapping of the anterior and posterior groups. The anterior group develops from points inferior to the attached border of the middle nasal concha, and the posterior group from points superior to this attached border. Even before puberty the cells may extend into the supraorbital plate of the frontal bone, and into the infraorbital plate of the maxilla. The fully developed ethmoidal labyrinth occupies

illary, etc. An absolute division of the ethmoidal cells into an anterior and posterior group is impossible. For practical purposes, however, we can call the anterior and superior cells the anterior ethmoids, and the posterior and inferior cells the posterior ethmoids.

Sphenoids. The sphenoidal sinus in early childhood may be of importance clinically and by the second year may have assumed proportions sufficiently large to become the seat of pathological processes and to retain infectious material within the sphenoid cavity. In its initial growth

into the sphenoid bone the sinus has a tendency to develop in the dorsolateral plane at the expense of its direct ventrodorsal growth. This leads to an early thinning of the lateral walls of the sinus and to relatively thick septal and dorsal walls.

Technique. Our technique of roentgen examination of the nasal accessory sinuses consists of the taking of six separate exposures or views of the sinuses on two

FIG. 3. Sinus technique. Film 1. Top half of film showing position for frontals and anterior ethmoids. Lower half of film showing position for antra.

FIG. 4. Sinus technique. Film 2. Top half of film showing position for sphenoids and posterior ethmoids. Lower half of film showing on left the lateral exposure for frontals and posterior ethmoids, and on the right the lateral exposure for sphenoids.

8 × 10 films and one small mouth film. We use throughout the double screen, duplitized film technique and an average spark gap of about 4½ inches. The posteroanterior views are made under compression with a 4-inch Kelly-Koett cone. The lower half of an 8 × 10 cassette is covered with a piece of sheet lead. In the center of the upper half of this cassette the inferior frontal region (glabella) is centered, the patient prone on the table with the forehead and nose touching the cassette, the arms extended alongside of the cassette. The central ray is directed through the head in a posteroanterior direction at an average angle of 17°. Compression of the head is used to prevent its movement during exposure. This film gives maximum information concerning the frontal and anterior ethmoid sinuses on posteroanterior view, and gives a check also on the condition of the posterior ethmoids and maxillary sinuses.

The upper half of the first cassette is covered and upon the lower half the exposure for the maxillary sinuses is taken, using the standard Waters' position, with the nose and chin touching the cassette. The central ray is directed in a posteroanterior direction through the head centering on the antra, and with the antra in the center of the exposed area. The average angle used in taking this exposure is about 18°, but the angle is varied for heads of different shape. This view gives maximum information concerning the condition of the antra, a check on the frontals and but little information concerning the remaining sinuses.

The second film shows three exposures. On the upper half of this cassette is taken the posteroanterior view of the anterior and posterior ethmoids and sphenoids, with the central ray directed upwards at an average angle of 10°, centering on the glabella and with the ray passing through the superior portion of the sphenoidal sinus. The glabella is centered on the exposed area, as for the frontal exposure. This view gives the density, size and outline of the sphenoidal sinus superiorly, projected into the frontal region. It also

On one of the lower quarters of this second cassette a lateral view of the frontals and posterior ethmoids is made, which gives valuable information concerning the depth of the frontal sinus, and the projection of frontal cells into the horizontal plate of the frontal. The thickness of the anterior frontal plate, shown by this view, is valuable in appreciating the significance of frontal density. Additional information is also obtained concerning the posterior ethmoid density, though the two sides are superimposed in this view.

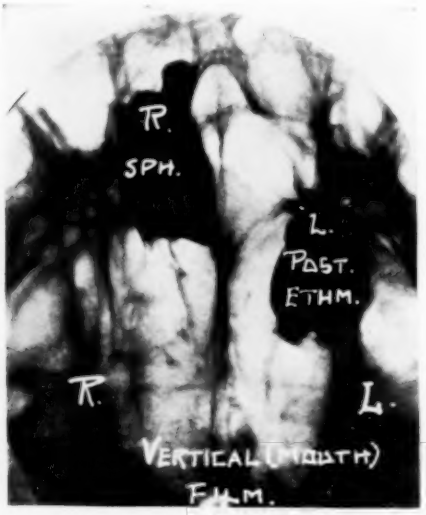


FIG. 5. Dried skull experiment. Left posterior ethmoids and right sphenoid filled with bismuth paste. Mouth film for demonstration of posterior ethmoids and sphenoids.

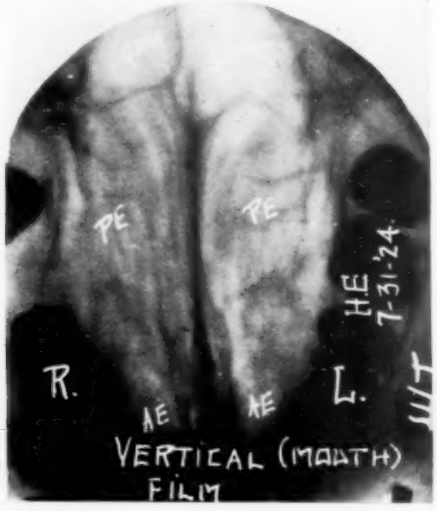


FIG. 6. Sinus technique. Mouth film (taken in horizontal position) for demonstration of posterior ethmoids and sphenoids. Exposure Number 6.

shows the superior curved line of the sphenoid, called by Granger the Y line. This line is important, in addition to the density of the sphenoid, in the determination of sphenoid sinus pathology. In cases where the frontal sinuses are involved, unilateral, small or absent, less reliable information is obtained from this view concerning the sphenoid sinuses. This view shows just below, and often partially superimposed upon the sphenoids, the posterior ethmoid cells. Valuable information concerning the density of the posterior ethmoids is often obtained from this view. The anterior ethmoid cells are projected just below and to the outer side of the posterior ethmoid field. It therefore gives a check on the anterior ethmoids also.

On the remaining quarter of the cassette a lateral view of the sphenoid is made, using a small cone centering over the sella turcica. This view gives information concerning the extent of pneumatization of the sphenoid bone, a general impression of the sphenoid density, and often some information about the posterior ethmoid cells, which lie immediately in front of the sphenoid. The two sphenoids are likewise superimposed in this view, giving less reliable information about the sphenoid density, unless both are clear.

The sixth exposure is made on a small film held in the mouth, using a specially designed cassette, fitting snugly so as to prevent moving about. The patient lies on his back on the roentgenographic table,

the head and shoulders on a hard pillow, the head horizontal. The central ray is directed through the top of the head at an average angle of 90°, centering through the sphenoid onto the mouth cassette. The cassette is placed in the mouth about 3 inches. The width of the cassette is 2⅝ inches. The taking of a vertical or mouth film for demonstration of the sphenoid was first described by Pfahler. The special cassette was designed by one of us (J.A.) shortly afterward, giving better screen-film contact, and insuring better negatives. We believe the placing of the patient on the table with the head and shoulders resting on a pillow, is an important modification of Pfahler's technique. This position is much more comfortable for the patient, there is less possibility of movement on his part, and the technique gives uniformly satisfactory sharp negatives.

On this film we obtain on the end farthest in the mouth the sphenoid sinuses, lying just posterior to a line drawn through the last molars. In front of the sphenoids, in a roughly quadrangular area, are the posterior ethmoid cells. This film gives maximum information concerning the posterior ethmoids, valuable information concerning the density of the sphenoids, and at times slight information concerning the density of the anterior ethmoids.

Experimental work on the dried skull, with the sphenoids, posterior and anterior ethmoids filled with an opaque substance, has demonstrated the normal landmarks for these views, which are, for practical purposes, constant in all examinations.

Various techniques have been described for the roentgenographic examination of the nasal accessory sinuses, many of them, in our opinion, incomplete. There cannot be sufficient emphasis placed upon the importance and necessity of having a complete and thorough roentgenographic examination in all cases of suspected sinus disease. We believe that it is necessary to take at least six separate views, in different directions, and from different angles, to adequately demonstrate all of the sinuses. The value of several views is that one is enabled to check each sinus on several views. The frontal sinuses, in our examination, are checked on three views, the maxillary sinuses on four, the anterior ethmoids on three, the posterior ethmoids on three, and the sphenoids on three. Often the appearance of a sinus will be suspicious on one view, while examination of it on another view will rule out the presence of pathology. Accuracy of interpretation of course is of primary importance in this as in other roentgenographic work.

The interpretation of the resulting negatives obtained by the use of our technique, of course, is a personal factor, and the value of the interpretation naturally depends upon the degree of knowledge of the roentgenologist concerning sinus disease and the anatomy of the nasal accessory sinuses. One must also be familiar with the variations in structure of the various sinuses and must also appreciate the various structures, normal and abnormal, which might be superimposed upon the shadow of the sinuses.

The diagnosis of frontal and antral pathology offers no special difficulty. The pathology of the anterior ethmoid group of cells, resulting in cloudiness of the group of cells lying to either side of the midline, just below the nasion, is somewhat more difficult of correct interpretation. The only absolutely essential requirement of the fronto-anterior ethmoid view is that the head be in such a position that the central ray is projected through the head in the median sagittal line. The smallest amount of rotation to one side or the other results in an increased density of one side which may be present without pathology.

The posteroanterior oblique film, used first by one of us (J.A.) early in 1921, and illustrated in a paper read before the Annual Meeting of the Idaho State Medical Society, Twin Falls, Idaho, Oct. 6–7, 1921, we believe to be a valuable film to check on the sphenoids, posterior and anterior ethmoids, and also on the antra. The density of the sphenoid on this oblique view will often be of considerable value. The value of the Y line of the superior border of the sphenoid sinus is conceded, being indistinct in pathological conditions of this sinus. When a thorough examination

of the sinuses is made this view must be included, but we do not believe it is the most valuable view.

The importance of the lateral view of the frontals is evident for determination of the depth of the frontals, the thickness of the anterior frontal plate, and the extension into the horizontal plate of the frontal bone. The posterior ethmoid block of cells is well shown on this view. The lateral view of the sphenoid shows, as before stated, the degree of pneumatization and the density. Pathology is shown by cloudiness of the sphenoid cells.

The most valuable film for demonstration of the sphenoids and posterior ethmoids we believe to be the vertical or mouth film. In our technique this view is better called the horizontal or mouth view. Ordinarily there are no confusing structures superimposed on the sphenoid density on this film. On the posterior ethmoid cells, however, the density of the intranasal structures may be superimposed. Thickened turbinates give increased density in this portion of the film. In this case one must rely upon the sharpness of outline and distinctness of the septal markings, in conjunction with the findings on the other views, in arriving at an appreciation of the importance of an increased density of the posterior ethmoid area on the mouth film. Careful examination of the frontal and antral films will usually demonstrate the presence of unusual intranasal thickening or turbinates.

In conclusion, we wish to emphasize the importance of a careful and complete roentgenographic examination of the nasal accessory sinuses, using at least six separate exposures and views. Careful checking of the sinus densities on the respective views we believe to be an essential feature of correct diagnosis and interpretation. We believe that there is no just ground for the pessimism displayed by rhinologists with respect to the roentgenographic examination of posterior ethmoids and sphenoids. A careful examination by a competent roentgenologist should be of great value in arriving at an accurate and complete diagnosis in cases of sinus disease.

A SIMPLIFIED TECHNIQUE FOR MAKING ROENTGENOGRAMS OF THE MASTOID IN THE LAW AND ARCELIN POSITIONS

BY AMEDEE GRANGER, M.D.

NEW ORLEANS, LOUISIANA

THE LAW POSITION

PLACE between the cassette covered with the Granger mastoid localizer and one end of the roentgenographic table two 13° angle blocks, one inclined towards the opposite end of the table, the other towards one side of the table.

FIG. 1.

2. The patient lies prone on the table, one arm and hand alongside his body, the other hand on the side of the angle blocks.

FIG. 3.

3. With the pinna held forward, one mastoid region is placed on the cassette (the other half of the cassette is protected by the leaded half of the mastoid localizer) the nose resting firmly on the adjustable fiber slide, the septum and alveolar border pressed firmly against one side of the U-shaped opening in the vertical portion of the mastoid localizer, the glabella and the supra-orbital region against the other side (Figs. 1 and 2).

FIG. 2.

FIG. 4.

4. The tube is focussed so that the central ray is directed toward the mastoid region in contact with the cassette.

The same procedure is then repeated to make the other mastoid on the unexposed portion of the film. The entire operation requires much less time than formerly and the result is most satisfactory.

THE ARCELIN POSITION

1. Place a cassette covered with the Granger localizer to the vertical portion of which a small shelf has been previously attached, on a 13° angle block inclined towards the end of the roentgenographic table on which it lies.

2. The patient lies prone, supported on the elbows, with the half of the forehead on the side to be roentgenographed in contact with the cassette, the chin resting on a small pad about one inch thick and the occiput inclined towards the small shelf of the mastoid localizer until the free edge of the pinna rests against it (Figs. 3 and 4).

This gives the approximate 50° rotation of the head found necessary by Arcelin to cause the superior border of the petrous portion of the temporal bone to lie parallel to the cassette.

The other mastoid is taken in the same manner on the unexposed portion of the film.

A SAFETY DEVICE FOR THE CARE OF RADIUM CONTAINED IN NEEDLES AND CAPSULES*

BY G. E. PFAHLER, M.D.

PHILADELPHIA, PENNSYLVANIA

IN handling radium salts in the form of needles, capsules and plaques, we are confronted by three serious dangers. One is the damaging effects to our bodies, the second is the damaging effects upon photographic materials in a roentgen laboratory, and the third is the danger of the loss of radium.

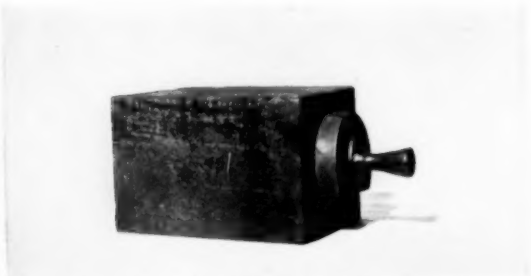


FIG. 1. Shows lead block of a size to fit a compartment in the safe, and which allows 2 inches of lead on each side of the radium, thereby giving ample protection against the gamma rays when surrounded by the 4 inches of steel of the safe.

We have experienced all three of these dangers, and the necessity for precaution against such dangers has forced us to develop a simple device which may be helpful to others. Therefore I take the liberty of describing it briefly with illustrations.

At the present time I have half a gram of radium in the form of 42 needles, 4 capsules and 2 plaques. This is capable of giving considerable radiation effect, and several years ago we found fogging of our roentgen films and of our photographic films. The radium had been kept in a steel safe, the walls of which are approximately

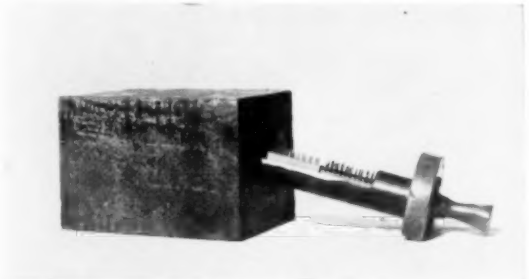


FIG. 2. Shows the radium container which fits in the hole of lead block, which has 2 inches of lead in the block plus a collar of 1 inch of lead. On the inside of this trough there is a block of wood with a hole for each radium needle, and at the sides specific places for each of the capsules and plaques, so that a glance can determine whether any radium is missing.

4 inches thick. The photographic and roentgen-ray plates were kept in a lead lined box beyond two walls and at a distance of about 20 feet. This seemed to us to be sufficient protection, but after a

* Read at the Ninth Annual Meeting, AMERICAN RADIUM SOCIETY, Chicago, Ill., June 9–10, 1924.

time we realized that the fogging of our films was caused by radium.

We then measured one of the compartments in the safe, and my mechanic cast a lead block to fit this compartment. The walls of this block are approximately 2 inches thick in all directions from the radium container which is placed on the inside. This 2 inches of lead, together with the walls of the safe have given us complete protection both to our bodies and the photographic films.

The third danger, however, was not so well avoided. The number of needles in the container, together with the other specimens, were not quickly counted, and on one occasion 50 mg. of radium, in the form of five 10 mg. needles were found missing. It developed that these had been missing for several days. The exact responsibility and location could not be determined. The radium was later found in dressings, in the midst of waste material which had been transported to the basement. We then added a block of wood to this radium container, which has a hole for every needle, and if at any time in looking over these specimens a hole is not filled, the location of the radium needle must be explained. The capsules and radium plaques are also seen at a glance. In this way repeated inspection of the radium with thorough control of the quantity is always at hand.

BOOK REVIEWS

Books Received Are Acknowledged under Heading: Books Received. This must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

DIE RÖNTGENSTRAHLEN UND IHRE ANWENDUNG. By G. Bucky, M.D. Second edition. Cloth. Pp. 120, with 95 illustrations. Leipzig and Berlin: B. G. Teubner, 1924.

This brief survey of the subject of roentgenology comprises Volume 556 of the series published by Teubner. The purpose of the series is to present in short monographic form up-to-date summaries of the various fields of the arts and sciences. In the present volume Dr. Bucky, a physician, writes with a threefold purpose in view. He assays an exposition of the subject that will instruct the intelligent layman in the range and general aspects of this field of science. He offers to the medical practitioner a brief and necessary introduction to roentgenological theory and practice. To the roentgenologist, he presents a general survey which includes some of the important advances made since the appearance of the first edition in 1918.

The section on physics leads from an elementary introduction to the phenomena of cathode rays and roentgen rays, the characteristics of gaseous and of vacuum roentgen tubes and of high tension currents. Chapters are presented on the technical arrangement of roentgen apparatus, on the nature of the roentgen picture and on auxiliary apparatus. A brief chapter is devoted to the application of roentgen rays in medicine, and the concluding chapter treats of the application of roentgen rays in other fields such as crystallography, crystal structure and atomic structure.

This little volume contains many illustrations which are clear and instructive. It is completely adequate as a brief, elementary introduction to theoretical roentgenology and its various applications.

BARNETT COHEN.

THE TREATMENT OF THE COMMON DISORDERS OF DIGESTION. By John L. Kantor, Ph.D., M.D., Chief in Gastrointestinal Diseases, Vanderbilt Clinic, Columbia University, Associate Gastroenterologist and Associate Roentgenologist, Montefiore Hospital for Chronic Diseases, New York City. Cloth. Price, $4.75. Pp. 245, with 64 illustrations. St. Louis: C. V. Mosby Co., 1924.

The author of this book is a clinician and roentgenologist. He offers the book as a guide in the treatment of common digestive disorders. It not only outlines treatment but tells you how to handle your patient. The author offers a gauge of his skill when he says: "To one familiar with these facts it should be self-evident that a fundamental principle in dealing with functional disorders is to treat the patient behind the disease. Whereas, in an organic condition, we focus directly on the organ or lesion in question; in the neuroses, we reverse the binocular, so to speak, add distance to the perspective, and include the whole patient, his mental as well as his physical background, and as much of his environment as is possible."

Kantor devotes the entire book to the intimate details of the treatment of gastrointestinal diseases. There are some fifty roentgen illustrations of excellent quality and with excellent descriptive legends. The roentgenologist will wish a few more words than Kantor offers upon the roentgen diagnosis of the conditions he describes, especially in the three chapters upon the treatment of constipation. He offers special advice upon atonic and spastic constipation, dyschezia, redundant colon and mucous colitis. Perhaps these are easily differentiated, roentgenologically, by Kantor, but the reader would ask for some little diagnostic data where the several treatments are laid down rather dogmatically.

The chapter titles include the following: General Management of Functional Digestive Disorders: Treatment of Ptosis and the Asthenic State; Treatment of the Syndrome of "Gastric Irritation;" Treatment of Gastric and Duodenal Ulcer; Treatment of Delayed Gastric Emptying; The Treatment of Achylia Gastrica; The Treatment of Gall-Bladder Disease; The Treatment of the Diarrheas; Treatment of Headaches Associated with Indigestion.

This book reminds one of a very good French table d'hote dinner. It is interesting and tantalizing but not sufficiently filling. You feel like saying, "Well that's a fine meal. Let's have another." A companion volume upon Kantor's methods of roentgen diagnosis in the several functional disorders he describes would be greatly appreciated.

E. H. SKINNER.

MIND AND MEDICINE. By Thomas W. Salmon, M.D., Professor of Psychiatry in Columbia University. Pp. 32. New York: Columbia University Press, 1924.

The finest things, as usual, come in the smallest package. This address upon "Mind and Medicine" was given by Dr. Thomas W.

Salmon at the opening session of the College of Physicians and Surgeons, Columbia University, September, 1923. It is published in March, 1924. Salmon's theme is that scientific medicine has too much neglected the psychic factor in disease. He reminds us of the amazing amount of mental disorder, collectively termed insanity. The psycho-neuroses, including hysteria, neurasthenia, anxiety, fear, doubt, morbid fixation, "shell-shock" and war neuroses add tremendously to the number. Salmon speaks of the way the profession confuses these disorders and how doctors attempt to transform these neuroses into physical disease and failing to obtain results, discard the poor mental wreck to quacks and cultists. He censures the profession for its unfortunate failure to appreciate the gravity of mental stress and strain.

The author considers that eventually the isolation of the insane will be an absurdity and that they will be cared for in suitable general hospital wards. He agrees with Dr. Wilbur that "the human mind, the human will and human personality will be as important for the medical student as typhoid fever, small-pox and cholera." Salmon believes that a "new kind of medical education will train physicians to deal with the *total reaction* of human beings, mental, physical and social."

This essay is most agreeable reading. It is stimulating to the jaded shadow-chaser. It takes one from the scientific pursuit of mechanical medicine into the art of healing those who are sick in mind as well as body. It forces an interest in the mental factors of early functional disturbances which may eventually become pathological.

E. H. Skinner.

BOOKS RECEIVED

X-rays and X-ray Apparatus. By John K. Robertson, Associate Professor of Physics, Queen's University, Kingston, Canada. Cloth. Pp. 228, with 112 illustrations. New York: The Macmillan Co., 1924.

Précancer. By C. Stajano, Montevideo.

Tecnica de microscopia y quimica-clinica. By Dr. Solano Ramos, Professor Auxiliar y Jefe de Laboratorio de la Catedra de Quimica-Biologica y Microscopia y Quimica Clinica. Second Edition. Paper. Pp. 366, with 130 illustrations. Habana, Cuba: Hermes, 1923.

INTERNATIONAL ABSTRACTS OF ROENTGEN AND RADIUM LITERATURE

ROENTGEN DIAGNOSIS

BROWN, CHARLES L., AND STIEFEL, DANIEL M. A case of multiple bone lesions of atypical roentgenographic appearance with the pathologic findings. *J. Bone & Joint Surg.*, July, 1924, vi, 550–563.

The patient was a girl 20 months old, with a history of exposure to a tuberculous father. She gave a positive von Pirquet reaction, a positive intradermal tuberculin reaction, and the clinical and roentgenographic findings in the lungs seemed to warrant the diagnosis of tuberculosis. The child developed multiple bone lesions, but the roentgenograms of these lesions were so different from the appearance usually associated with tuberculosis and so similar to the appearance usually associated with syphilis that it was the consensus of opinion to diagnose the case as one of tuberculosis and congenital syphilis combined.

Roentgenograms of the upper extremities showed an extensive periosteal reaction along the shaft of the right ulna and marked periosteal reaction with some destruction in the lower end of the shaft of the left ulna, and a slight periosteal reaction along the shaft of the left radius. A roentgenogram of the lower extremities showed rather diffuse periostitis along the shafts of both tibias and a definite destructive process in the lower end of the left fibula. There was no joint involvement. Autopsy and pathological examination showed foci of tuberculous osteomyelitis in all of these bones together with sequestrum formation, destruction and the very striking formation of new subperiosteal bone.

This case illustrates the difficulty of differentiating roentgenographically between pyogenic osteomyelitis, tuberculosis and syphilis. It furthermore offers an opportunity for correlating definite pathological findings with an atypical roentgenographic appearance. It furnishes a striking example of a predominantly formative reaction in tuberculosis of the bone.

ELWYN, HERMAN. A case of acute abscess of the lung complicated by massive collapse of the lung. *Boston M. & S. J.*, June 26, 1924, cxc, 1108–1111.

The case described presented the unusual picture of an acute abscess in the right lower lobe complicated by a massive collapse of the entire right lung. It is suspected that the abscess followed an aspiration pneumonia acquired in swimming. As the right lung became inflated, the abscess cavity in the right lower lobe made itself apparent on roentgen examination.

It is believed that massive collapse is due to a constriction of bronchioles of the whole or part of the lung brought about reflexly by way of the vagus. Such a reflex constriction of the bronchioles may be brought about not only by impulses from the gastrointestinal tract as in postoperative massive collapse, but also from the lung itself, as in this case.

HEISE, FRED H., AND SAMPSON, HOMER L. An attempt to classify by means of the *x*-ray cases of suspected and definite pulmonary tuberculosis showing less than a definite parenchymatous *x*-ray lesion. *Am. Rev. Tuberc.*, July, 1924, ix, 406–408.

The roentgenograms from a small number of selected cases from the following groups were studied: (1) nontuberculous, (2) those with a history of hemoptysis, (3) of pleurisy with effusion, (4) of positive sputum, and (5) those with a combination of 2 or more findings under (2), (3) and (4). The films were freely mixed and an attempt was made to place each film in a group representing the closest definite roentgen-ray evidence of pulmonary tuberculosis. Those having root shadows were placed in one class, the second included those with isolated tubercles, the third those with peritruncal tubercles, the fourth those with definite pleuritic changes, and the fifth those with indefinite but probable parenchymatous change.

A comparison was then made of the clinical features of the individual cases with the roentgenographic characteristics of the five classes of films. The striking feature of the study was the absence of a history of pleurisy with effusion or of hemoptysis and absence of tubercle bacilli and râles in the root, isolated tubercles and peritruncal classes. In other words, the more nearly the roentgen-ray findings approach the parenchymatous type, the more frequently one or more of the criteria of a positive diagnosis are found. No deaths occurred from pulmonary tuberculosis except in the probable parenchymatous class of patients.

LUND, CHARLES C., AND RITVO, MAX. Postoperative massive collapse of the lungs. *Boston M. & S. J.*, June 26, 1924, cxc, 1103–1107.

This condition is found to follow certain injuries or operation not involving the lungs or

pleura. Roentgenograms show that it is very different from the ordinary postoperative pulmonary complications. In some cases the condition is discovered only on physical or roentgenologic examination of the chest, other symptoms being practically negative. The roentgenogram shows a markedly diminished radiance over the affected portion of the lung; the shadow may be somewhat mottled in character. The heart and trachea are markedly displaced to the affected side, the diaphragm merges with the shadow above it and its outline is obliterated at first. As the chest clears the diaphragm on the side of the collapse is found to be elevated, and its respiratory excursions diminished or absent. The latter symptoms may remain even after all other signs have disappeared. A striking feature is that the patients at the height of this condition show no signs of reaction and frequently do not know that there is anything wrong. The prognosis in general is good; whereas in conditions that simulate collapse such as postoperative lobar pneumonia, edema or massive infarction the prognosis is grave.

Two cases are described in detail. The massive collapse occurred in both suddenly, about thirty hours after operation. The physical and roentgen-ray examination showed typical findings in every respect.

The cause of massive collapse of the lungs is believed to be the plugging of bronchi with mucus. The recumbent posture and protective muscular spasm resulting from the wound are important predisposing factors. The air behind the plug is absorbed by the lung and once this absorption has started a vicious circle is initiated, for with the small amount of air a relatively greater muscular effort is necessary for a cough to create enough pressure to dislodge the plug.

MOORE, B. H. Radius curves (Madelung's wrist). *J. Bone & Joint Surg.*, July, 1924, vi, 568–574.

A report is given of 2 cases, one occurring in a 16-year old girl and the second in a 15-year old boy. The roentgenographic evidence seems to support the theory that this condition is caused by a faulty growth of the epiphysis. The triangular area of lessened bone density at the lower end of the radius is very noticeable and has apparently not been mentioned in the literature. It suggests very strongly a cessation of the growth in the epiphyseal line. As the bone grows in length and also in diameter, a cone-shaped area of less dense bone would be formed. The more rapid growth of the unaffected portion would produce distortion of the radius, and the ulna growing more rapidly would necessarily push the hand forward but itself backward. In the second case the defect in the epiphysis is very evident in the stereoscopic roentgenogram. The cause for such a sharply localized injury to the epiphyseal line is still obscure. A very low-grade bacterial infection might produce this injury. At any rate, the deformity appears to be one of those affecting the epiphysis of growing bone, thus placing it in the class with Legg's "flat head" deformity of the femur.

ROENTGEN AND RADIUM THERAPY

BURNS, FREDERICK S. Radium in the treatment of non-malignant diseases of the skin. *Boston M. & S. J.*, July 3, 1924, cxci, 16–20.

Radium therapy of the skin demands two essential qualifications; first, the training of a dermatologist, and second, special training in the technique of radium as applied to the skin. In the use of radium for non-malignant disease of the skin, constitutional reactions do not occur for the reason that only small amounts are required. In the human skin the cells of the germinal layer, hair papillae, the sebaceous and sweat glands, the endothelial cells of the blood vessels and fixed connective tissue cells are radiosensitive. The non-nucleated elements such as the hair, and elastic and collagenous connective tissue are only slightly susceptible. Direct bactericidal action on bacteria in tissue by radium without serious damage to the tissues cannot be obtained.

Keloids, vascular and pigmented nevi, lymphangiomata, benign cystic epitheliomata, synovial cysts, and rhinoscleroma are the most important of the benign tumors of the skin removable by radium. The use of radium is best restricted to small keloids and bands of scar tissue for the reason that roentgen rays can be better applied to much larger surfaces. The importance of early diagnosis in these conditions should not be overlooked. Keloids should be irradiated to the extreme depth of their bases. For small keloids one-fourth or one-half strength flat applicators may be used, screened with 0.1 mm. lead or 0.4 mm. Al, applied next to the skin for 2 to 4 hours. Proper screening prevents development of telangiectasis.

Of the vascular nevi, small port wine marks may be removed with one-fourth to one-half strength applicators screened with 0.1 mm. Al. Larger lesions are difficult to treat evenly with radium, and better results in the large port wine nevus are obtained with the water cooled ultraviolet ray lamp. Cavernous angiomata give especially satisfactory results with radium. One-half and full strength applicators may be

used screened with 0.1 mm. lead with exposures of 1 to 2 hours. The dosage depends on the thickness of the vascular tissue to be broken down. Deeper angiomata require considerable gamma radiation to bring about their involution. For this type, radium in tubes, emanation or full strength applicators should be employed, at least 50 per cent of the hard beta rays being filtered out either by brass or lead filters or by metallic filters combined with distance filtration.

Radium has no selective action on pigmented nevi. Their removal by radium is consequently effected by the caustic and exfoliative effect of the softer beta rays. An average dose of 2 to 3 mg-hr. screened with rubber only is usually safe and successful. Minute pigmented nevi are best removed by other methods. Lymphangiomata and multiple benign cystic epitheliomata are removed in almost miraculous fashion with practically no scarring in the latter condition by treatment with radium.

Three small wens have been cured by radium. The content of the cysts was first evacuated and the surface then treated with 10 mg-hr., screened with 0.4 mm. Al.

There is a group of affections that may be classed as of inflammatory and uncertain etiology which are symptomatically healed by radium. This group includes lupus erythematosus, psoriasis, lichen planus, and chronic ezema. Superficial hypertrophies of the skin curable by radium are keratosis senilis, verrucae, callosities, and occasionally clavi.

The dangerous and painful keratoses developing in atrophic skin resulting from roentgen-ray dermatitis will almost always disappear under the action of the beta rays of radium. Soft beta rays and small doses should be given, on an average about two-thirds the amount that would be used in an ordinary senile keratosis. The use of radium for the removal of superfluous hair should be condemned. Better results without danger can be accomplished by electrolysis.

Brehm, W. Sclerotizing strumitis with compression of the larynx as a late roentgen injury following thyroid irradiation. *München. med. Wchnschr.*, June 6, 1924, lxxi, 750–751.

Details are given of a case occurring in a girl twenty-one years old, who had received three treatments one month apart to reduce an enlarging thyroid. The roentgen radiation applied consisted of 180 Fürstenau units at 40 cm. focal distance, 4.5 ma., 1 mm. Al plus 0.5 mm. Zn, at the first treatment; the second was 195 Fürstenau units, 4 ma.; and the third, 240 Fürstenau units. About a year later the patient complained of difficulty in breathing which was fast becoming serious. Roentgenogram of the trachea showed a high-grade compression only laterally at the level of the second to the fourth cervical vertebrae. Operation disclosed the hard thyroid tissue adhering with great tenacity to the surrounding tissues and clamping down upon the trachea. A section 1 cm. wide had to be removed from the edge of each lobe in order to release the pressure. The operative wound at the site of the roentgen injury naturally did not heal with normal speed, but the healing tendency was still very much greater than that occurring in an ulcer immediately following a roentgen burn.

Hoarseness setting in gradually long after roentgen irradiation has not a good prognosis. It is almost always a forerunner and the first sign of a delayed roentgen reaction. In the thyroid, the reaction consisted of a strikingly dense tissue formation and firm adhesions to the surrounding tissues. There was an increase in the interstitial connective tissue, and relatively many follicles contained no colloid. The profuse development of an extraordinarily dense fibrous, partly hyaline connective tissue was the outstanding feature of the microscopic examination.

Corbett, J. J. The effect of radium on glaucoma. *Boston M. & S. J.*, June 26, 1924, cxc, 1124–1126.

Attention is directed to what is considered a spectacular result of radium treatment of glaucoma. It was found that the radiation definitely reduces the intraocular tension and at the same time may improve the vision. The matter of dosage has not been worked out in all its details. It will be necessary to determine whether best results will come from large doses given at long intervals or small doses at frequent intervals. The present impression is that there is more good to be expected from one large dose than from several small doses. In treating glaucoma, the alpha and beta rays should be screened with brass and hard rubber. With the radium placed 2 cm. from the eye this screening makes available the gamma rays without any danger of burning. Three cases are described in detail in males, 62, 46 and 59 years old respectively. Treatment was successful in relieving the intraocular tension but it is pointed out that radiation is not a substitute for myotics or operation.

Corbett, J. J. Radium clinic for treatment of eye, ear, nose and throat conditions. *Boston M. & S. J.*, June 19, 1924, cxc, 1082–1084.

The outstanding feature about the work in Boston City Hospital clinic is that at least 98

per cent of the cases in which radium is used are non-malignant. It is believed that as radium becomes better understood and its uses more diversified its application in the non-malignant field will become the most important field of its usefulness.

In the treatment of tonsils the conclusion was reached that the quickest and most effective manner to use radium was in the form of needles plunged into the body of the tonsil and allowed to remain there. Fifty mg. of radium have been used for periods varying from 15 minutes to one hour without any serious reaction. These treatments were repeated at weekly intervals. It is pointed out that in the treatment of tonsils, radium should be given only secondary consideration. If operative treatment is contraindicated, the radiation becomes second choice.

Another field of usefulness has been in the treatment of corneal scars. Definite improvement in vision has resulted after such treatment. In 4 cases, 2 nebulae of the cornea disappeared entirely, while the other 2 showed very definite thinning out. In corneal scars which are not too dense a clearing up of the scar and an improvement in vision can be demonstrated.

GREENOUGH, ROBERT B. The treatment of malignant diseases with radium and *x*-ray —cancer of the cervix. *Surg., Gynec. & Obst.*, July, 1924, xxxix, 18–26.

This constitutes the preliminary report of the Committee on the Treatment of Malignant Diseases with Radium and *X*-ray appointed by the American College of Surgeons. The treatment of cancer of the cervix was selected as the first subject for investigation. A total of 1210 case records were abstracted for analysis from large clinics in Boston, Chicago, New York, Philadelphia, Toronto, Baltimore, Cleveland and Scranton. The cases selected for study were all treated in the years 1914–1919 inclusive. During the period concerned in this investigation high voltage, short wave-length roentgen therapy was not in common use and no cases were recorded in which roentgen rays were employed except as an adjunct to other methods. To judge the value of the roentgen ray from these data is therefore quite impossible.

A number of the records were rejected for one reason or another and there remained 829 cases satisfactory for study. Of the latter 94 were free from disease three or more years after treatment. More than half of these "cures" were obtained by the use of radium and roentgen radiation without radical operation. There were no "cures" by cautery alone.

In 243 cases of early favorable, or borderline type, hysterectomy alone "cured" one in 3 with an operative mortality of one in 5. Radium with palliative operation (cautery) "cured" about one in 3, and radium alone (or with palliative operation) about one in 5. Under these conditions it may be said that a choice between operation and radium in the treatment of early and favorable cases of cancer of the cervix is an open one. It is to be borne in mind that the results of treatment by radium used with the technique of the present day are not yet available but that it is generally believed that they will be better than the figures here presented.

In more advanced cases the "cures" either by radiation or by hysterectomy were very few (6 per cent). The duration of life in the unsuccessful early cases is somewhat greater after radium than after operation. The formation of rectovaginal and vesicovaginal fistulas occurred with nearly equal frequency under all methods of treatment (between 5.5 and 7 per cent).

Radium with or without roentgen radiation or palliative operation was the most important agency in the destruction of local disease in cases which failed to obtain a "cure." The value of radium as a palliative measure in advanced cases is beyond dispute. In the treatment of recurrent cases after hysterectomy and in cancer of the cervical stump radium is to be preferred to other methods. A sufficiently large dose of radium is necessary to obtain destruction of the local lesion. The treatment of cancer of the cervix with inadequate amounts of radium should not be encouraged. A uniform classification of the pathological varieties of cancer of the cervix is much to be desired.

DERBY, GEORGE S. *X*-ray and radium in the non-malignant diseases of the eye. *Boston M. & S. J.*, July, 3 1924, cxci, 20–21.

There are two classes of cases in which treatment with roentgen or radium radiation is of negative value. The first is trachoma and the second is cataract. Conflicting views have been expressed with regard to these two conditions, but the present opinion is that radiation treatment is not so effective as other forms of treatment.

There are but few conditions of non-malignant disease of the eye and adnexae in which radium and roentgen radiation seem to be of some definite benefit. In vernal conjunctivitis (spring catarrh) roentgen and radium radiation have been shown to be efficacious. As yet much remains to be ascertained as to the best method of application, the optimal dose and the number of exposures necessary.

The other field of usefulness for radiation therapy is in xanthelasma of the lids; and also in extra-ocular vascular tumors such as nevi,

angiomata, lymphangiomata, hemangiomata and cavernous angiomata.

HOLMES, GEORGE W. Radiation therapy of the thyroid and ductless glands. *Boston M. & S. J.*, July 3, 1924, cxci, 10–12.

The thymus gland, particularly when hyperactive, is easily affected by roentgen or radium radiation. The roentgen-ray diagnosis of enlarged thymus or thymus disease is extremely difficult. It is believed that the use of roentgen rays as a means of demonstrating the absence of thymus before operation is a dangerous procedure and very likely to give a false sense of security. The diagnosis should be established upon the clinical findings, the roentgen-ray evidence being used only for confirmation. Benefit from the roentgen-ray treatment may appear within the first twenty-four hours, or it may be a week before becoming evident. Usually one treatment is sufficient, although occasionally two or three are necessary. The treatment should never be prolonged and at no time should more than two-thirds of the erythema dose be given. Medium length roentgen rays are applied to the upper thorax, one-half of the erythema dose being applied to the front and a similar dose over the back. A case of enlarged thymus in a male aged seven months is described. Roentgen-ray treatment caused cessation of spasm in two weeks.

In the treatment of goiter proper selection of the cases for radiation is highly important. The early, distinctly toxic case is especially the one to be selected. The author is inclined to favor the radiation treatment of suitable goiter cases. A case of exophthalmic goiter in a man forty-two years old is described. Response to treatment of this mild early case was obtained in the short period of four months without interfering with the patient's mode of living or occupation.

In the treatment of goiter, exposure is made over three areas, two over the thyroid and one over the thymus region in such a manner that each lobe of the thyroid is exposed, and the larynx avoided as much as possible. A 12-in. target skin distance is used with a medium wave-length. The amount given at each exposure should be accurately measured, should not exceed two-thirds of an erythema dose and should not be repeated within three weeks. The number of treatments in a given case should not exceed seven; five or six are usually sufficient. Prolonged treatment should never be given as permanent injury may result. The patient should be cautioned against applying ointments to the neck or long exposure to the sun.

HOLMES, G. W., MEANS, J. H., PORTER, C. A., RICHARDSON, E. P., AND STARR, M. P. On the treatment of exophthalmic goiter. *Boston M. & S. J.*, Aug. 14, 1924, cxci, 295–300.

In order to answer the question as to what is the best way to treat exophthalmic goiter an intensive study was made by clinical and laboratory means of groups of patients treated by various methods. The basal metabolic rate taken in conjunction with the clinical findings constituted the criterion whereby the efficacy of the various methods was established. In examining the effects of roentgen-ray treatment it is pointed out that about one-third of the cases show no evidence of improvement on irradiation. In the other two-thirds there was evidence of improvement. In some patients the effect of roentgen treatment is extraordinarily good. The benefit of roentgen-ray treatment is less certain than by any other method. If it occurs at all it makes itself apparent within four months.

The effects of operative treatment are more constant. Partial thyroidectomy is followed by much improvement which seems proportional to the relative amount of thyroid tissue removed. The results at the end of a year are little, if any better than in the roentgen-ray group. On the other hand, the effect of subtotal thyroidectomy is very striking and far more constant than that of any other procedure. At the end of a year the basal metabolic rate of plus 3 per cent shows that the procedure employed has accomplished all that could be expected. Following subtotal thyroidectomy, when the metabolism has returned to normal limits it remains there apparently permanently.

In 50 per cent of the cases in which Lugol's solution was administered there occurred a drop in the basal metabolic rate and improvement in symptoms which were as rapid and as great as that following subtotal thyroidectomy. However the iodine is a palliative, not a curative agent. It is useful as a preparation for operation, because it accomplishes what was formerly sought with roentgen-ray, namely reduction in intoxication before surgery is begun, only it does it more certainly and more quickly. Lugol's solution reduces the toxic reaction which follows operation in patients with exophthalmic goiter. The present conclusion is therefore that iodinization followed by subtotal thyroidectomy while the metabolism is normal is the best program for the treatment of exophthalmic goiter that has yet been advanced. Roentgen radiation will still have its place in patients in whom operation is undesirable or who refuse operation. Iodine has not been found to contribute anything to the success of irradiation. It may be that development of the methods of applying irradiation may improve the therapeutic results.

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